THURSDAY, JUNE 2, 1898.

SYSTEMATIC BACTERIOLOGY.

System der Bakterien. Handbuch der Morphologie, Entwickelungsgeschichte und Systematik der Bakterien. Allgemeiner Theil. By W. Migula. Vol. i. Pp. 368; 6 plates. (Jena: Gustav Fischer, 1897.)

APPLIED or technical bacteriology in recent years has developed so rapidly, that in the rush after new discoveries the study of systematic bacteriology has been almost entirely neglected. With the introduction of Koch's methods the separation of bacteria was made an easy matter, and when it became evident that a large number of pathological lesions are caused by micro-organisms, bacteriology was introduced into the medical laboratories, and undoubtedly the pathological bacteriologist has greatly advanced our knowledge of the action of bacteria in health and in disease. Until Pasteur appeared, those lowly organisms had been unobtrusively studied in botanical laboratories, but the discoveries of this immortal genius revealed to all how great a share the bacteria have in the preservation of health and the causation of disease, in the sorrows and pleasures of life. Discovery after discovery in the causation of disease has led to triumph after triumph in prevention and cure; the study of fermentation has led to the perfection of important industries, and even now an appeal is made to the bacteria to keep our surroundings in a good sanitary condition. Bacteriology was so keenly studied by medical men that at one time there was almost a danger lest all micro-organisms were regarded as our foes, and yet their friendly acts greatly outweigh the harm that they do to us. Now, however, this is fully recognised, and just as at one time disease-producing bacteria were searched for, so at present the tendency is to seek after useful micro-organisms and to sing their praises. In this country, as usual, we are slow to encourage the study of applied bacteriology; in our midst it is yet fighting its way into medicine, and there is still an appalling ignorance of bacteriology even amongst the youngest physicians and surgeons; the British brewers are just beginning to see what Denmark and Germany saw years ago, and in agriculture we pin our faith on lectures and feeble examinations instead of opening research laboratories for the study of bacteriology as applied to the dairy and the soil. However, the records of other countries show us what practical bacteriology has achieved in a short time.

The never-ceasing discovery of new bacterial forms by men who have no knowledge or sympathy with systematic botany has led to serious confusion, especially in medical circles. It is their practice to describe an organism, at once to give it a name, often derived from the lesion it produces, and to claim for it a specific place in nature, without attempting to define its proper position in a systematic classification. The confusion about the choleraic vibrio is not yet entirely cleared away; thirty and more varieties have been described as different species, and now in the case of the diphtheria bacillus the number of pseudo-forms increases rapidly. The medical bacteriologist is too much influenced by simple staining reactions, and morphological appearances or biological and chemical phenomena, and he distinguishes species by most inadequate tests. It is therefore a matter of congratulation to be able to welcome two works on bacteriology, founded upon botanical principles, such as Prof. Migula and Prof. A. Fischer have offered. Here we shall speak only of Prof. Migula's "System of Bacteriology."

The author begins with a concise critical account of the historical development of systematic bacteriology from Leeuwenhoek to our present time. It must be a relief to many that Prof. Migula considers it almost useless waste of thought to ponder over the question whether bacteria are plants or animals; since they must be placed somewhere, we may without hesitation classify them among the plants, not because they possess a vegetable nature, but because their nearest living allies are found among the plants. The different systems proposed by Cohn, Zopf, Flügge, de Bary, Hüppe, Eisenberg, Miquel, Fischer and others are discussed and criticised. A classification on the principle of fructification is impossible, because we cannot honestly accept the existence of arthrospores, and thus there is no *fundamentum divisionis;* nor can we classify bacteria according to their chemical, physical and physiological properties, as proposed by Eisenberg. Prof. Migula justly repudiates the extraordinary artificial and unnatural system of Miquel, which was founded upon the constancy of physiological properties. As it is a habit of medical bacteriologists, even at the present time, to distinguish species or varieties on such a principle, which has also been ably criticised by Prof. Marshall Ward, we advise them to glance at pp. 42 and 43, which should convince them of their error. Prof. Migula's system is as follows:—

BACTERIA.

Family I.—Coccaceæ.

Species 1. Streptococcus = division in one plane.
2. Micrococcus = division in two planes.[1]
3. Sarcina = division in three planes.
4. Planococcus = division in two planes; flagella.
5. Planosarcina = division in three planes; flagella.

Family II.—Bacteriaceæ.

Species 1. Bacterium = no flagella.
2. Bacillus = completely surrounded by flagella.
3. Pseudomonas = polar flagella.

Family III.—Spirillaceæ.

Species 1. Spirosoma = no flagella; rigid.
2. Microspira = 1, or 2–3 polar flagella; rigid.
3. Spirillum = 5–20 polar flagella; rigid.
4. Spirochæte = no flagella; flexible.

Family IV.—Chlamydobacteriaceæ.

Species 1. Streptothrix.
2. Cladothrix.
3. Crenothrix.
4. Phragmidiothrix.
5. Thiothrix.

Family V.—Beggiatoaceæ.

Species Beggiatoa.

The morphology of the bacterial cell is carefully described, and considerable attention is paid to the cell-membrane, which, according to Prof. Migula, is directly

[1] It is pleasing to note that the term "staphylococcus" does not occur this system.

continuous with the flagella where they exist. The latter cannot be traced into the substance proper of the cell, a statement which the writer of this review, from his own studies, especially on the bacillus of tetanus, is not prepared to accept. The question whether bacteria possess a nucleus is discussed at length, and the author concludes that true nuclei have not been detected, and it is improbable that they exist. All the granules or structures hitherto described as nuclei, cannot possibly be regarded as such; this is clearly shown by Fischer's researches on bacterial plasmolysis. In studying the minute details of the bacterial cell, Prof. Migula rightly insists upon the absolute necessity of starting from the normal living micro-organism. Extremely interesting is the masterly discussion of the nature of the granules and vacuoles observed in the substance of the bacterial cell, of the origin of polar staining and segmentation. In this section the subject of plasmolysis is carefully considered. The granules so frequently observed he regards as the rudimentary nucleus of the bacterial cell, but he frankly admits that this view is based entirely on personal opinion. One of the best portions of the book is the section on the flagella, which recently have been diligently studied also by Fischer, who has proved that these fascinating structures are the motor-organs of the mobile micro-organisms, and who has attempted to classify the bacteria according to the arrangement and distribution of their flagella. Prof. Migula concludes that all flagellate schizophytes, excepting Spirochæta and Beggiatoa, are bacteria, and that different species belonging to the same family can be distinguished by their flagella; and herein all who have experience of flagella staining will agree with him: the number of flagella, their mode of insertion, and their shape and curves—all these points must be noted.

The growth and division of the bacterial cell is described with eloquent fulness. The mode of division is a generic character in the coccaceæ; it is constant, and a coccus dividing in one plane by no manner of means can be made to divide in two or three planes. But, furthermore, it is a fundamental distinctive feature between the coccaceæ and the other bacteria; for the latter divide only in one plane, and the division is always preceded by an elongation of the cell in a direction at right angles to the plane of division. Until recently it was stated that cocci are as long as they are broad, and that by such measurements they can be distinguished from the bacteria; but Prof. Migula insists that we must abandon this unsatisfactory distinction in favour of the one just enunciated. The bacteriaceæ always divide at right angles to their long axes, and we must therefore take exception to the statements, recently made in certain quarters, that the diphtheria bacillus divides parallel to its long axis. Of the branching of streptococcus chains he gives two satisfactory explanations: (1) occasionally in a long chain a coccus becomes twisted so that its plane of division is turned in a different direction; (2) a few links in the chain die, and are overgrown by the survivors. This branching therefore does not signify a mycelial ancestry. After division has taken place, the organisms may be arranged as diplo-cocci, strepto-cocci, tetra-cocci, or as sarcinæ; but it is absurd to use the terms diplo- and tetra-coccus as generic ones, for many organisms belonging to different genera may present all these forms. The chapter on spore formation occupies fifty-three pages, and is a masterly account of the subject, from which a few points may be quoted. The so-called arthrospores cannot be distinguished from ordinary vegetative cells, and cannot therefore be regarded as spores, so that the endospore is the only recognised spore. Physiological properties, such as resistance against heat, desiccation, or antiseptics cannot decide the nature of a spore; the only true criterion is germination, a process differing in essence and in principle from ordinary vegetative proliferation by division. The formation and structure of the spore are described with a wealth of detail which omits no important fact. Broadly speaking, germination may occur in three ways: (*a*) the membrane of the spore remains unruptured, either persisting as the membrane of the young bacterium, or being dissolved during the process of germination; (*b*) the spore-membrane is ruptured at one or other pole, allowing the young bacterium to glide out; or (*c*) it is ruptured equatorially; but in each case there are numerous minor variations and deviations from the type, depending partly upon the conditions under which the germination is observed. A nucleus so far has not been demonstrated in the spore, although recently Hegler claimed to have done this. We must fully agree with Prof. Migula when he expresses the opinion that so long as we are ignorant of the natural conditions of bacterial growth, we are not in a position to use the faculty of spore formation for the purpose of systematic classification, for many bacteria which at present are described as asporogenous under more natural conditions than the gelatine or agar-agar tubes can supply, may actually form spores.

Everybody will turn with interest to the chapter on Pleomorphism and Variability, which opens with a historical account of the views held since Nägeli's time. Nägeli in almost unpardonable and unintelligible manner ignored all morphological and physiological characters of the bacteria, and became the master of the reckless apostles of pleomorphism. Their creed led the philosophic Buchner into the almost amusing error of proclaiming the identity of the hay bacillus and the anthrax bacillus, and caused the illustrious Billroth to blunder with his *Coccobacteria septica*. Prof. Migula insists that species must be determined by identity in development and growth and constancy of morphological characters; but as yet our microscopes are not perfect enough to detect the minutest morphological differences, and therefore for the present, in many cases, we must fall back upon biological characters. Varieties are by no means constant, and widely different forms may constitute a species. It is impossible here to discuss the question more fully; those who take an interest in such matters must consult the original.

In the last 100 pages the biological characters of the bacteria are discussed; the different nutrient media and the methods of cultivation; the formation of pigments (which are subdivided according to their solubility in water and alcohol); the products of fermentation and of metabolic activity, and the pathogenetic properties of the bacteria. To the medical bacteriologist the chapter on infective micro-organisms is an important one. For practical purposes it is proper to distinguish between pathogenetic and non-pathogenetic organisms, but this dis-

tinction cannot be recognised in systematic bacteriology. Prof. Migula invites the botanist to follow the methods of the medical bacteriologist in the study of bacterial diseases of plants, which he regrets in most cases has been undertaken in a slipshod and careless manner. He gives a number of plant diseases, said to be due to bacteria, to expose the manner in which the subject hitherto has been approached. Anaerobiosis and phosphorescence, the thio-bacteria and ferruginous bacteria form the subjects of the next few chapters, and then we come to an interesting and concise account of the nitro-bacteria; the volume is concluded by two short chapters on the influence of heat and light on bacterial growth.

We may disagree with the author here or there, but we, and especially the medical bacteriologists, must welcome the appearance of this work. The volume is the result of Prof. Migula's own labours and studies pursued for many years with true German industry, and this enhances its value considerably. It is well written, and the language is not particularly difficult; the literary references at the end of each chapter are excellent. It is impossible to read the book without regretting that the second volume has not yet appeared. Six plates accompany the text, but, by an oversight, plates iv. and v. have been placed and numbered in wrong order, and must be transposed. A. A. KANTHACK.

THE PHYSICAL PROPERTIES OF CRYSTALS.

Die fundamentalen physikalischen Eigenschaften der Krystalle in elementarer Darstellung von Dr Woldemar Voigt, o.ö. Professor der Physik an der Universität Göttingen. (Leipzig: Veit and Co., 1898.)

PROF. VOIGT is well known for his researches into the physical properties of crystals. Not only is the mathematical theory of large parts of the subject due to him, but the experiments on which the theory is built were largely made by himself and Prof. Riecke, and many of the instruments used were invented or improved by him. His latest contribution to the science is a little book, half-way between a popular exposition and a technical treatise. Last year Prof. Voigt lectured at Göttingen on crystals to teachers in the upper classes of secondary schools, and these lectures form the basis of the book before us.

Prof. Voigt is a mathematician, and though the mathematics is here reduced to a minimum, he assumes a knowledge of the elements which his hearers doubtless possessed. A command not of facts and formulæ, but of mathematical and physical ideas and terms is required for a satisfactory study of the book. In particular, some familiarity with the use and transformation of co-ordinates is essential. In England, where the knowledge of elementary mathematics is widely spread, this little volume ought to find many readers, and a good translation is to be desired.

We have before us no mere text-book, but a book with an idea and a plan. Round the idea the facts are grouped, and one is carried on naturally from one set of properties to another. After a preliminary chapter on the symmetry of crystal forms, the leading idea is developed in the second chapter. Prof. Voigt points out that, in investigating the relation between cause and effect, it is allowable to treat not only effects but causes as states of matter. For instance, electric phenomena produced by heat may be regarded as the relation between the temperature and the electrical state of a body. Temperature is determined by a scalar quantity, and the electrical state of any particle by a vector. This vector is, moreover, a so-called polar vector, *i.e.* one, like a translation, whose components change sign when the sense of all the coordinate axes is changed, in contradistinction to a so-called axial vector, whose components retain their signs. Temperature involving no direction, the direction of the vector can only be determined by the crystalline structure, and we should expect such a relation to be possible in acentric crystals possessing one single polar axis of symmetry, such as tourmaline. In fact, the pyro-electric properties of tourmaline have been known for 200 years.

Besides scalars and vectors there is a third kind of quantity, by which a state of tension or dilatation is characterised. It is determined by a magnitude and a straight line, undetermined in sense. Prof. Voigt calls such a quantity a *tensor*, and three mutually perpendicular tensors a *tensor-tripel*, giving in the preface his reasons for the adoption of a new term, and pointing out that in doing so he is merely extending the use of the word in quaternions. By means of these three kinds of quantities and their mutual relations, he is able to classify, in the manner indicated, the different phenomena. In every case we have two effects due to the same cause, and the primary effect is taken to represent the cause in its relation to the secondary effect. Each chapter after the second exhibits such a relation. We have an example of the relation between a scalar and a tensor-tripel in that between temperature and deformation, between a vector and a tensor-tripel in piëzo-electricity, and numerous examples of two vectors; elasticity is treated as a relation between two tensor-tripels.

The method gives more than a mere classification, as the example shows. It enables us to say *à priori* whether a given body, isotropic or crystalline, is capable of exhibiting certain phenomena. In general the phenomena which are *à priori* possible, are *à posteriori* known to exist. In one case, however, referred to in Chapter iii., a set of phenomena represented by the relation between a scalar and an axial vector, theoretically possible in a large class of crystals, has never been observed, and it remains open to question whether the failure to observe pyromagnetic phenomena is due to an unknown point of theory or to unsuspected difficulties of observation.

In the chapter on the symmetry of crystals, Prof. Voigt takes three typical forms—Iceland spar (rhombohedron), tourmaline, and quartz—and he derives the two latter from the former by the simple process of joining together two "half rhombohedra." In spite of three excellent figures, the explanation would not be comprehensible without previous knowledge of the way in which the rhombohedra are to be divided. Even the simplest crystal forms are hard to understand without a

model, and one could wish, in addition to the figures, for diagrams of models to be made in folded paper.

One purely external fact may be noted about the book: unlike most foreign publications, it can be bought neatly bound in buckram.

W. H. AND G. CHISHOLM YOUNG.

MODERN DEVELOPMENT OF THE ATOMIC THEORY.

The Arrangement of Atoms in Space. By J. H. Van 't Hoff. Second revised and enlarged edition, with a preface by Johannes Wislicenus, &c.; translated and edited by Arnold Eiloart. Pp. xi + 211. (London: Longmans, Green, and Co., 1898.)

THE history of the development of that department of science which it is now usual to call stereo-chemistry is extremely interesting. While it shows that great results often spring from small beginnings, it also shows that although genius may discern in apparently trivial phenomena the basis of very far-reaching ideas, it requires the united efforts of a large number of workers both to extend the applications of the idea and to render its foundation firm and secure. In 1848 Pasteur discovered that racemic acid, itself possessing no action on a ray of polarised light, is resolvable into two acids, each of which rotates the plane of polarisation in equal but opposite directions, and that this property of optical activity is associated with hemihedrism in the crystalline form. Not till more than a quarter of a century later, namely in September 1874, did Van 't Hoff give to the world his ideas on the representation of chemical structure in space. Two months afterwards similar views were put forward by Le Bel. So far as it obtained any notice at all, the new theory was received chiefly with ridicule. It is now accepted by the whole chemical world.

Nearly all the difficulties attending the new doctrine were cleared away in Van 't Hoff's "Dix Années dans l'histoire d'une théorie" (1887), and since that time a new chemical literature has sprung up devoted to the exposition of the doctrine and its application to the large number of examples now known. This little book will be useful to students looking at the subject from the theoretical point of view. And perhaps it supplies all that is really desirable, inasmuch as it provides freely references to the original papers of the numerous chemists who have worked experimentally upon the subject; and so, perhaps, the lack of detail as to methods is less likely to be felt. Dr. Eiloart, the translator of the volume, is known as an investigator of stereo-chemical problems, and he has published a useful "Guide to Stereo-chemistry," based on lectures delivered by him a few years ago in the Cornell University. The translation may be therefore trusted to represent accurately the views and intention of the author. The worst that can be said is that the exposition is in some places rather scanty, as, for example, in all that relates to the supposed configuration of the nitrogen atom, no alternative views being considered. There is an interesting appendix, containing a note by Prof. A. Werner, of Zürich, on the application of stereo-chemical ideas to the isomerism of metallic compounds, more especially to the plato-ammines and cobalt-ammines. The configuration of the groups MA_6, in which M is the metal and A the group NH_3 or some negative radicle, is represented by a regular octahedron, the metal occupying the centre, and the groups having their places at the solid angles. This accounts for the existence of two isomeric forms of these compounds, but the reader is left to find out for himself in what manner the ionisable radicles which enter into the composition of the salts are attached to this octahedral arrangement. It is interesting to find that the possibility of applying stereo-chemical ideas to elements other than carbon and nitrogen is at last beginning to be recognised by chemists. W. A. T.

OUR BOOK SHELF.

The Linacre Reports. Vol. iii. 1895–1897. Edited by E. Ray Lankester, M.A. (London: Adlard.)

THIS volume contains eighteen papers published by Prof. Lankester and his staff at Oxford since the summer of 1895, together with the reports of the teaching in the department over which he presides, and a list of the zoological additions to the Museum during the past two years.

As a record of work done in the laboratory at Oxford it compares favourably with the two volumes which preceded it, and proves that the energy and perseverance in research of the Oxford zoologists still form one of the most gratifying features of the science schools of that University. Although one-half of the papers in the volume deal with the morphology of segmented worms, the others treat of animals in widely separated classes, showing that under the guiding influence of Prof. Lankester the school is not likely to suffer from the spirit of hasty generalisation on the one hand, nor from the evils of narrow-minded specialisation on the other.

Two papers by Mr. Goodrich on the Cœlom theory and on the homologies of the Annelid prostomium can be compared with Prof. Benham's papers on certain Earthworms. The former may be taken as admirable examples of biological reasoning and clear statements of views, the latter as examples of laborious and valuable investigations of anatomical details. Prof. Lankester may be heartily congratulated upon this further proof of the stimulating influence of his teaching, and upon the skill and zeal of his friends and pupils at Oxford.

S. J. H.

Anatomia Vegetale. By Dr. F. Tognini. Pp. 274 (Milan: U. Hoepli, 1897.)

Fisiologia Vegetale. By Dr. L. Montemartini. Pp. 230. (Milan: U. Hoepli, 1898.)

THESE two handy little manuals are both apparently largely based on the "Lehrbuch der Botanik" by Strasburger, Noll, Schenck and Schimper. The vegetable anatomy, by the late Dr. Tognini, is a good account of the leading features of the science. More attention is devoted in it to the histology of plants than to their gross anatomy. The small size of the book necessitates a sketchy treatment of the subject, and the descriptions in several instances are meagre. Thus the structure and arrangement of the bast is dismissed in a few words, while scarcely anything at all is said of the changes which take place in the sieve-plates. However, much accurate information is contained in the book, and a great deal of the results of recent investigations are

included in it. The illustrations are good and numerous; they are to a large extent either drawn specially for the work, or are taken from Briosi and Tognini's work on *Cannabis sativa*.

Dr. Montemartini has succeeded in getting a large quantity of sound information into his short treatise on "Plant Physiology," and he has made it more useful by citing the chief literature of each subject in a list at the end of each chapter. It is curious to note that he quotes the ringing experiment, as used by Hales, to demonstrate the ascent of water in the wood. In the "Vegetable Statics," however, this experiment is described to prove that there is no great downward motion of water in the bark. With regard to the problem of the ascent of water in trees, Dr. Montemartini accepts the hypothesis which maintains that the sap is drawn up in a tensile state. In each section the principal facts are well described, and the book is well up to date. The section on growth is perhaps the best in the book, and contains a short account of the author's own researches. The last section in the book is on reproduction, and too short to be of much use.

Glass Blowing and Working. By Thomas Bolas. Pp. 212. (London: Dawbarn and Ward, Ltd.)

CONSIDERING the practical importance of glass-blowing, not only in physical and chemical laboratories but in many manufactures, it is remarkable that so few works have been written on the subject. English students are practically restricted to Mr. Shenstone's well-known little book, and the chapters in Prof. Threlfall's "Laboratory Arts." The present work, which is based upon a course of lectures given by the author in connection with the Technical Education Committee of the Middlesex County Council, is quite distinct in character from either of these, and in some respects, perhaps, is less suitable for a beginner. The opening chapters are devoted to glass-working tools, the most important of which, of course, are the blowpipe and the bellows. The remarks on these are practical and lucid, the author showing that the ideal blowpipe and bellows differ considerably from those usually found in chemical and physical laboratories. The chapter on minor tools and appliances is very full, although many of the instruments described are but rarely used by professional glass-blowers. The chapters on glass manipulation contain nothing essentially new, the only points which seem somewhat unorthodox to one accustomed to the German style of glass-blowing being the method of making the inside seals in "traps," and the use of lead glass. The author is a strong advocate of the use of the latter, and indeed regards the blackening in a reducing flame as a positive advantage to the beginner, as compelling him to work with a flame in which the combustion is complete. The latter part of the book gives instructions for making small decorative articles at the blowpipe, with notes on the preparation of enamels and coloured glasses. Many useful recipes are given throughout the book, mostly published for the first time, of which the various inks for etching and printing on glass may be specially mentioned. If only as a collection of practical hints, the book is certain to be found on the shelves of all amateurs in this fascinating art.

Experimental Mechanics. By G. H. Wyatt, B.Sc., A.R.C.S. Handbooks of Practical Science, No iii. Pp. 54. (London: Rivingtons, 1898.)

A NUMBER of simple experiments in mechanics, most of them quantitative, are described in this book. The experiments are capable of being performed by pupils who can understand the descriptions of them, and they will train the hand, mind and eye to work together.

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.*]

Notes on the Bugonia-Superstitions.—The Occurrence of *Eristalis Tenax* in India.

IN consequence of a notice published by Baron C. R. Osten-Sacken in NATURE (vol. xlix., p. 198, December 28, 1893), requesting the public for information about the folk-lore of the Oxen-born bees, I made to him several communications, most of which were incorporated in his subsequent works: namely, "On the Oxen-born Bees of the Ancients" (Heidelberg, 1894), and "Additional Notes in Explanation of the Bugonia-Lore," &c. (*ibid.*, 1895).[1] Continuing since in the researches, I have collected the following notes, which I trust you will allow me a space to publish, inasmuch as the latter work (p. 4) contains the author's indication that he shall thereby conclude his publications on this subject:—

(1) *The Occurrence of the Bees in a Skull.*—Besides the two instances of this incident quoted in "O. B." (pp. 64, 3) from Herodotus and from Patterson, we find another case in Purchas's "Pilgrimes." 1624, Part III., l. iii. p. 627, where Geo. Berkeley, the English merchant (*c.* 1605), narrates from his personal observations that Livonia was then so much devastated by the Russians that, her woods were "strowed with bones of the dead carcases, and himselfe did once in one of those woods, eate Honey out of a man's skull wherein a swarm of bees were, and bred as it hanged on a Tree."

(2) *Chinese Lores in Relation to the Bugonia.*—Mr. G. B. Buckton, in his "Natural History of *Eristalis tenax*," 1895, p. 79, gathering from "O. B.", includes Japan and China among the countries that "have been all more or less affected by this strange idea." Should a reader infer from this passage that the Japanese and the Chinese ever dreamt of the breeding of honey-bees from bovine carcases, gross must be his blunder. He can find in "O. B." a reproduction of my clear statements of the absence from those nations of this belief (p. 20), and of the early Japanese discrimination established between bees and drone-flies (p. 33).

However, the exposition of Mr. Buckton could excellently apply to the case of the Chinese, provided the term "Bugonia-superstition" be used in such an extensive sense as to cover all allied beliefs derivable from the confusions of bees and drone-flies. As the result of my research for three years past, I can now enumerate altogether three instances of such beliefs from Chinese source: firstly, a notice of a literatus in the beginning of the seventeenth century, who apparently mistook some *Eristalis* for honey-bees (see NATURE, vol. l. p. 30, May 10, 1894); secondly, an inveterate fallacy current among the renowned naturalists in China, that the bees use human urine for manufacturing honey[2] ("O. B.," p. 19; "A. N.," pp. 17, 19–20); and thirdly, a passage which I have lately found in "Koo-kin-tu-shu-tseih-ching" (Peking, 1726, Sec. IV., tom. lxviii, "Ki-i-pu-wei-kau," i. fol. 2, *b.*), and reads thus:—"Should a hen's egg turn into bees or wasps, it would portend the town where it happens to become totally evacuated in subsequent time."

Here I may add that, although the Chinese were singularly free from the barren speculations on the artificial breeding of honey-bees from dead oxen, yet they did not escape the invasion of another enterprising illusion, which might have rivalled the Bugonia-craze in its absurdity. It is described by Chang Hwa (232–300 A.D.) in his "Poh-wuh-chi" (tom. iv. f. 7, *a*, Jap. ed., 1683):—"Tear the Turtle (*Trionyx*) into pieces about as large as stones used in the game of Ki (a sort of chess); mix them well with the juice of the Chih-hien (the red variety of *Amaranthus mangostanus*), and bury them underground in a thick envelope made of the Imperata-grass; thus, after ten days, you will find each piece of flesh changed into a turtle." Another book, named "Pi-ya Kwang-yau," is said to relate: "If a carapace of the turtle be wrapped with the Amaranth and placed

[1] For brevity's sake I shall use in this article the abbreviations "O. B." and "A. N." respectively for these works.

[2] So, Li Shi-Chin, one of the greatest naturalists China has ever produced, praises the Bees in a similar tone to Samson's riddle by saying: "Out of the fetor came forth deity; and out of the decay came forth mystery" ("Pan-tsau-Kang-muh," 1578, *sub.*, "Mih-fang")

on damp ground, it turns into another turtle: now there are men who use to divide into pieces the turtle's flesh, and by adding to them the Amaranth-juice, change them after ten days to turtles as minute as young silkworms, which they throw in ponds under the name of 'Seedling-Turtles' (*Chung Pieh*)" ("Yuen-kien-lui-han," 1701, tom. cdxli., art. "Pieh").[1] These preposterous schemes of multiplying by gemmiparone process one of the dainties dearest to the Celestial's palate, were doubtless an outcome of erroneous observations, whereby those credulous folks mistook for newly hatched turtles some insects of a turtle-like configuration with the habit of thronging about the putrid animal substances.[2]

(3) *Japanese Lores concerning Eristalis tenax.*—"In regard to the composition of honey and the confusion of the honey-bee with *E. tenax* [*cf.* (2) *supra*.], the Japanese nation was far in advance of its neighbours" ("A. N.," p. 19). Only single instance somewhat analogous to the old western stories of the Wasp and Hornet generated from dead horses, I have recited in NATURE, *ubi supra*, from a Japanese work. This is the belief in the "Horse-Hair Wasp," so-called from the popular notion of an ichneumon-fly whose ovipositors resemble horse-hairs, that it is a metamorphosis of the latter;[3] while, as Baron Osten-Sacken aptly expounds, the alleged Horse-born Wasp and Horse-born Hornet are both the issues of the ancients' confusion of *Helophilus* and *Gastrophilus*, with the hymenopters in question ("O. B.," pp. 53–55).

"The occurrence of *E. tenax* of Japan is of very long standing . . . the people did not confound it with the bee" ("O. B.," p. 33, note; *cf.* "A. N.," pp. 20–22). This Japanese immunity from the taint of such a widespread superstition, appears to be mainly due to their early ignorance of the bee-keeping.[4] Although Japan is not destitute of the indigenous bees (*cf.* Kaibara, "Yamato Hongô," 1708, tom. xiv. fol. 13), the comparative paucity in the old Japanese literature of the allusions to honey and bees, and a definite register in the national history of a failure in introducing them from Corea in 643 A.D. ("Nihongi," lib. xxiv.), together with the striking absence from the Japanese language of any native name of honey,[5] are sufficient to preclude any ideas of the original familiarity of the Japanese with apiary.

This primitive ignorance of the honey-keeping certainly gave great impulse to the early establishment by the Japanese of the demarcation between the bee and the drone-fly; which latter dipteron they have properly grouped with its allies, such as *Tabanus*, *Helophilus*, and *Gastrophilus*, under the general onomatope "Abu," which corresponds with "Mang," the Chinese appellation after their humming sounds—from the former, no doubt, descends the modern Japanese name of *E. tenax*, "Bun-bun" (*cf.* "O. B.," p. 20).

That the Japanese were early acquainted with the rat-tailed larva of *E. tenax*, is evinced in a cyclopædia compiled in 1713, wherein the imago and the larvæ of the fly are figured and described distinctly ("A. D.," p. 20). In an old vernacular leechcraft, the so-called "Long-tailed Dung-Worm" (*Onaga-Kusomushi*), the larva of the fly, was prescribed as an invaluable cure for rickets (*Kan*) (Terashima, as quoted in foot-note 4). Baron Osten-Sacken already gave from my communication to him a popular rhyme said to be efficacious in keeping this larva away from out-houses ("A. D.," p. 21). In some provincial versions of the rhyme, the larva is called "Kamisake-mushi" or "Kamisake-jorô" (*i.e.* Worm-or-Strumpet who avoids the [Shintoist] Gods).[1] "Eibian," a Japanese antiquary, understands this cursing poem to have been composed by a zealous Shintoist, who might have directed it against the Buddha Sâkyamuni, whom it represents by the loathsome larva, and whose birth took place on the day named in it (Yamazaki, "Seiji Hyakudan," 1841, chapter xli). This remark points at the remote antiquity of the Japanese acquaintance with the *ver à queue de rat*; for, according to it, the verses must have sprung in an epoch when the native and Indian creeds were yet contending greatly in Japan.

(4) *The Mithraic Association of the Bees with the Lion and the Oxen.*—Dr. Ernest Krause, in his article, "Die mythologische Periode der Entwickelungsgeschichte," in "Kosmos," Jahr. IV., B. viii. p. 350, Leipzig, 1880, ascribes the triple association of these creatures to the amalgamation of the Christian legend with the classic stories. Nevertheless, the fact that these *trio* were long in existence in Persia, before the introduction of Christianity into classic regions, is evident from the ancient cultus of Mithras, in which one who was initiated into the mystic grade of Lion had to "wash his hands with honey collected by bees who are Oxen-begotten" (Thomas Taylor, "Select Works of Porphyry," 1823, p. 181); added to which, on an ancient cylinder of recent discovery, those persons presiding on the Leontic rites, are said to be represented in the tunics and stoles covered with the design of honey-comb (F. Lajard, "Recherches sur les Cultes publics et les Mystères de Mithra," 1867, 2*e* Section, p. 240, *seqq.*).

(5) *Astronomical and Elemental Explanations of the Bugonia Myth.*—In his "A. N.," pp. 12–13, Baron Osten-Sacken names the three methods of treatments of this myth by the commentators on the classic passages that concern it. To those three, I may add as the fourth the following explanation by A. de Gubernatis, who endeavours to treat the myth astronomically: "According to Porphyrios, the moon (Selênê) was also called a bee (Melissa). Selênê was represented drawn by two white horses or two cows; the horn of these cows seems to correspond to the sting of the bee. The souls of the dead were supposed to come down from the moon upon the earth in the forms of bees. Porphyrios adds that as the moon is the culminating point of the constellation of the bull, it is believed that bees are born in the bull's carcase. Dionysos (the moon), after having been torn to pieces in the form of a bull, was born again, according to those who were initiated in the Dionysian mysteries, in the form of a bee; hence the name of Bougenês, given to Dionysos (moon). . . Sometimes, instead of the lunar bull, we find the solar lion" ("Zoological Mythology," vol ii. p. 217, London, 1872). The fifth method, as it might be, seeks in the Bugonia an "elemental" myth, as we find it in F. Lajard's work, quoted above. According to this authority, the Ox and the Lion appear to have symbolised in the creed of ancient Persians what the Chinese have designated respectively with the terms of "Yin" ("negativeness") and "Yang" ("positiveness") (*cf.* my letter in NATURE, vol. li. p. 32, November 8, 1894); and the Mithraic association of the Leontic grade with honey (compare last paragraph) is solvable by the reason that honey contains an essence extremely combustible (extremely "positive" in Chinese philosophy), which is wax (p. 242). It is highly probable that the association of the bees with the oxen existed in the same cultus of Mithras (*cf.* Taylor, *l.c.*), as we can adduce it from the Persian cosmogony, which states that, the First Bull, the first of all beings created by Armuzd, having been slain by the jealous Ahriman, his soul, the Ized Goschorum, issued from his left shoulder, and after collecting the sperm of the terrestrial bull, carried it to moon, where it became the germ of all creatures (see Lajard, p. 49; *cf.* the Dionysian story in (4) *supra*).

(6) *Bugonia-Superstitions in India.*—Once I communicated

[1] Perhaps "Hwin-nan-wan-pih-shuh," attributed to Liu Ngan (*c.* 179–122 B.C.), is the oldest work extant which mentions this sympathetic power on the turtle of the "Hien," which name comprises, besides all species of *Amaranthus*, the Purslane (*Portulaca oleracea*). Some authors who take for "Hien" the latter plant singly, tries to explain a passage in the "Book of Changes," where occurs the "Hien" with the *Phytolacca* (for the latter see my letter in NATURE, vol. liv. p. 343, August 13, 1896) as the types of diabolical plants, by conceiving as devilish the remarkable resistance to desiccation of the Purslane as well as its alleged influence on dead turtles (Chang Urh-Ki, "Hau-ngan-hien-hwa," tome i; Wu-Ki-Shun, "Shih-wohming-shih-tu-kau," ed. Ono, tome iii. fol. 19, *b*). It is a curious contingency that the word "Amaranth" is derived from Greek words—*a*, privative, and μαραίνω, to wither (Loudon, "Encyclopædia of Plants," 1880, p. 787). Also there is a Chinese belief in a visceral disease called "parasitic turtle" (*Pieh-hia*), said to originate in eating turtle-flesh with the Hien ("Yuen-kien-lui-han," *l.c.*; Chang Urh-Ki, *ut supra*), which error has probably arisen from their confusion of some parasitic flat worms with turtles.

[2] Cf. Pliny, H. N., xi. 20: "Sicut asinorum scarabaeos mutante natura ex aliis quaedam in alia." In Chinese glossaries there are names of many beetles founded on the resemblance to the turtle. Certain aquatic Heteroptera (*e.g. Belostoma indica*) that are perhaps the origin of the "Seedling-Turtle" story, are called in Japanese "Tagame," or "turtle in rice-field" (Terashima, "Wakan Sansai-dzue, 1713, tome liii.).

[3] For the assimilation of the ichneumon-flies with the wasps, cf. Pliny, xi. 24: "Vespae quae ichneumone vocantur." "Ma-fang" (literally, horse-wasp) occurs in Chinese; here, however, the epithet "horse" signifies "large" (cf. Kaibara, *op. cit.*, tome ix. fol. 10, *b*).

[4] Even in the sixteenth century the domestication of the bees must have been unknown, at least in some western provinces: for the fact is particularly called attention to in the narration of a Japanese ambassador sent to Rome by a prince in Kyûshû: "Non hanno in quei paesi Api, ne in consequenza il nobilissimo frutto del mele . . ." ("Breve Ragguaglio dell' Isola del Giapone, Roma, 1582, Brit. Mus., 10,055, a. 1, fol. 2, *a*).

[5] Only word ever used in Japan for honey is "Mitsu" (or "Michi" in its obsolete form), bore a modification of Chinese "Mih," and that for the honey-bee is "Mitsu-bachi," composed of the heterogeneous words "Wamyô Shô," written in the tenth century, tomes xvi. and xix.).

[1] So a rustic version runs: "Since long ago auspicious is the eighth of the fourth moon; on this day punishment of worms that hate gods is their doom."

to Baron Osten-Sacken my suggestion of the possibility of finding some traces of these superstitions from an Indian source; but it met his negative remark in "A. N.," *sub fin*, chiefly grounded on the alleged lack till that time of any report firm enough for the inclusion of *E. tenax*, among the Indian fauna. In a work of N. Müller, however, we have lately found described an old silver vase made in India, which has engraved thereon Kamadeva (the Love) in the act of producing Totma (the Force). It represents the infant god riding on his quiver,[1] from which a lion is issuing forth, while the quiver rests on the back of a bee, and, as is well known, a chain of bees forms the string to the god's bow. Another mythical picture of Totma described by the same author is a lion producing out of his mouth a swarm of bees and a cow ("Glauben, Wissen, und Kunst der alten Hindus," Manzig, 1822, B.I., S. 553, *seqq.*; with Tab. I., Fig. 11 and 12). From these figures we are perhaps right in believing that the Hindus were not totally unaffected with the Bugonia-myth; and if it be so, how anciently the myth existed in India? This is the question which I should solicit assistance from any of your readers to elucidate.[2]

(7) *The Occurrence of Eristalis tenax in India.*—To supplement the last paragraph, it will be interesting to introduce here the following letter from Mr. E. E. Austen, of the British Museum (Natural History), which I owe to his kindness:—

"November 16, 1897.

"*Eristalis tenax*, *L.* has never been recorded (at any rate, under its own name) from India. However, in a collection of Diptera from India belonging to the Bombay Natural History Society, and at present in my hands for determination, are four specimens which, in my opinion, undoubtedly belong to this species. I have not time just now to make minute examination, but so far as I can see these specimens agree perfectly with the normal European form. If there are any differences, I do not think that they can possibly be of *specific value*. Of the four specimens in question one is unlabelled; the other three are labelled respectively—'N. W. P.' (North-West Province), 'Himalayas,' and 'Musourie.' I may add that the Bombay Natural History Society's collection also contains five specimens (not labelled with precise localities) of *E. pertinax*, *L.*—a species which closely resembles *E. tenax*, and has identical habits. In England, at any rate, it is often the more abundant of the two.

(Signed) "E. E. AUSTEN."

In a Buddhist cyclopædia in Chinese (Tau-ngan's "Fah-yuen-chu-lin," completed 668 A.D., ed. 1827, tom. xxviii. fol. 12-13), there is a quotation from an Avadâna Sûtra, giving account of how Ananda found in a pond near Râdjagriha, which receives all sewerage of that city, a huge worm several tens of feet long, and without limbs, amusing itself among refuses, rolling, raising, and lowering. The question as for the cause of so unpleasant an animal, the Buddha answers by tracing it to a long past æon, when an avaricious abbot cursed good monks with very unwholesome words, which effected the malefactor's transmigration to such a disgusting life. Here, the worm in ordures is described too briefly, but its figures, except the exaggerated size, forcibly put me in mind of a similar account of the "Long-tailed Dung-Worm" by a Japanese author (see "A. N.," p. 21); which leads to the view that the Indians took early notice of the rat-tailed larva of some *Eristalis*.

(8) *Stingless Bees besides Eristalis tenax.*—From the instances I shall give presently it will be evident that the readers must take precaution against the hasty identifications with the *Eristalis* of all so-called "stingless bees." Thus, Prof. A. Merx, of Jena, suggests the possible identity with *E. tenax* of certain stingless bees in Abyssinia, which J. Ludolf records in his "Historia Æthiopica," 1681, lib. 1, chap. 13 ("O. B.," p. 67). But it is too evident from the following words that the identity is not true:—"De hoc accipiunt Habessini Mel agreste. . . . Quia verò aculeo carent, la tenebrâ se tuentur; sub terrâ enim favos condunt, angustissimo introitu, quem viso homine quinque vel sex implent capitula sua solo æqualia ponentes, tam solerter, ut acutissimos oculos fallant." Two manners of the "stingless bees" in the Western Hemisphere are respectively described by Fernandez d'Oviedo (1478-1557) and H. Schmirdel (*c.* 1534-54): both agree in building their nests inside of trees, where they make white excellent honey (Ramusio, "Navigationi e Viaggi," Venetia, 1606, fol. 51, A; Purchas, "Pilgrimes," Part III., l. vii., chap. 4). One who reads Astley's "Collection" (1745, vol. ii. p. 355), might naturally be struck with the thought that there *E. tenax* is meant by a "Drone-Bee" that "frequents the villages [in the western coast of South Guinea] . . . but yields no honey"; on examination, however, of the original of this passage, we confirm other insect is meant thereby, as the statement has this qualification:—"[They] hurt nobody unless provoked, and then their sting causes great and dangerous inflammations" (J. Barbot's "Description of Guinea," in Churchill's "Collection," 1732, vol. i. p. 116).

KUMAGUSU MINAKATA.

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P.S.—It may be not amiss to note here that the Spanish Benedictine, Benito Feyjoo, in his "Théatro Critico Universal" (Madrid, 1734, tom. iv. p. 198), devotes a chapter to the Bugonia, where he refers to Sperling's failure to find any bees from dead oxen while serious pestilence was prevailing among cattle in Würtemberg (see "O. B.," p. 61). He continues: "Doctor Don Joseph Ortiz Barroso, the learned physician in the city of Utrera, experienced the same failure on two several occasions of similar epidemic that visited the territory of Sevilla. The latter observations conflict with the solution which F. Sachs seeked to apply to the case of Sperling's failure, by attributing it to the too cold climate of Würtemberg for the bees; for the same failures were experienced in Andalusia, which is a quite warm country; while such coldest countries in the north as Russia, Podolia, &c., have great abundance of the bees, causing very cheap sale of honey and wax in those parts."

K. M.

Rainfall and Earthquake Periods.

WITH reference to the remarkable letter of "A. B. M.," which appeared in your number of this week (May 19), p. 31, as to the recurrence of cold and wet periods at about thirty-five years' interval (measuring from the centre of one such period to that of the next), I beg leave to call attention to the fact that thirty-five years represents a marked period of recurrence of maximum frequency of earthquakes, as I showed in a paper which was submitted to the Royal Irish Academy in 1887, but not published. That a relation should exist between earthquakes, volcanic disturbances, and the atmospheric conditions which determine wet and dry periods, seems to me more reasonable to accept *à priori*, than to assume that these phenomena are quite independent of each other.

From Mallet's Catalogue of Earthquakes I have compiled a list between the dates 365 and 1842, showing the intimate relations between the shocks and immediate and violent atmospheric perturbations on those occasions (about 500 in all); this list could be very much extended for more recent times from Perry's and Falb's lists, and would be a valuable contribution on the subject.

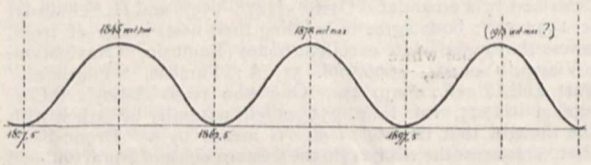
But discussing simply the figures presented by your correspondent from this point of view, very interesting results can be shown. I begin by assuming (*a*) an intimate though undefined relation between most great earthquakes and intense volcanic action; (*b*) intense volcanic action in one or other of the great volcanic centres or lines of action during certain periods, giving rise to the emission of vast quantities of gases which rise into the upper atmosphere, and disturb or influence the upper currents; and (*c*) that the upper currents of the atmosphere are more and more looked on as dominating meteorological phenomena. Hence a dependency in the meteorological conditions which determine maxima of drought or wet, on maxima of volcanic action, but not concordance as to date or period. These lag upon the former. This may be roughly shown from the figures given by "A. B. M." He gives the following dates as maxima of wet periods.

The commencement of the curve corresponds to about the year 1827·5, which of itself will be found to represent a year of maximum intensity of earthquakes (it is interesting to note the record for June 3 of that year in Mallet's Catalogue "Martinique."

[1] In this connection it is significant that "the Italian 'carcasso' means quiver, because it is encircled and kept together with iron rings or ribs, which resemble the ribs of a human carcase" (Webster's Dictionary).

[2] About four years ago, when I followed to the British Museum my master in Mantranism, Mr. Hôryû Toki, that Yogâtchâ rya informed the late Sir (then Mr.) Augustus Franks of the remarkable coincidences that exist between the characters of the Brahmamist "Kamadeva" (the Hindu Eros) and of the Mantranist's "Aizen Myôwô" (the bright king who soaks mankind with love). One conspicuous figure of the latter is his crown of a lion's head (see Butsuzô Dzui," n. e., 1886, tome ii. fol. 20, *a*), whence it is very probable that some vestiges of the Leontogenes occur in the "Aizen-kyô," a Buddhist sûtra devoted to this Vadjra, but inaccessible to me in this country.

"At the same time the rain fell after sixty-six days' drought, no such instance of dry weather in the West Indies was remembered). The next minima (of wet) would correspond to 1862·5 (great earthquake in Greece, 26 Dec./61, and eruptions of



Vesuvius accompanied by earthquakes), and the last, to 1897·5, which fairly corresponds to the great earthquake of Assam, so fully noticed in your journal, as one of the most intense of modern times. Moreover, these figures may be presented otherwise. Taking the great earthquake of Lisbon as of date 1755, roughly we have the annexed succession of years showing at the two extremes the dates (approx.) of two of the greatest earthquakes of modern times, and to some extent showing that thirty-five years represents a period of maximum earthquake action, and agreeing roughly with the intervals of extreme drought and with periods of great volcanic activity.

1755
+ 35
1790
+ 35
1825
+ 35
1860
+ 35
1895

As regards the year 1825, it is interesting to note that Mallet's Catalogue gives for July 26 and 27 of that year, "One of the most tremendous hurricanes on record occurred in the West Indies."

Of course a great deal has to be said as to the locality of the earthquakes, and as to the volcanoes to be considered. I certainly look on those of the Andes Cordillera as of prime importance by their influence on the upper currents.

Royal College of Science, Dublin, May 21. J. P. O'REILLY.

Ebbing and Flowing Wells.

A CASE somewhat resembling those previously described (NATURE, May 12, p. 45, and May 19, p. 52), occurs on the dormant volcano of Barren Island in the Andaman Sea. The only (comparatively) fresh water to be found on the island reaches the surface in the form of hot springs, which gush out close to the shore at the breach through the ancient cone. The springs are due to the percolation of the drainage water beneath the most recent lava streams, which have not yet fully cooled down. The level of the springs rises and falls with the tide, and the lower part of a well, which I caused to be dug in the ash about twenty yards from the shore, filled with hot water at the flow of the tide, and ran dry at the ebb. The bottom of the well was between tide levels. The water is brackish, but rather less so at high than at low tide, the reason of which appears to be as follows. The porous volcanic materials of the island below sea level are saturated by the water of the sea, the surface of this inland subterranean water rising and falling in connection with the rise and fall of the sea tide. The drainage of the amphitheatre, then, soaks downwards until it reaches the inland salt water, over which, on account of the difference in specific gravity, it flows onward to the sea. At high tide, therefore, the drainage reaches the sea through materials which have been comparatively little wetted by salt water, while at low tide it percolates through, and washes, ejecta from which the salt water has just retired. The phenomenon is, of course, complicated by the difference in time between the inland tide and that at sea.

The springs are described in some detail in *Memoirs Geol. Surv. Ind.*, vol. xxi. p. 274 (also *Records G.S.I.*, vol. xxviii. pp. 31, 34). F. R. MALLET.

May 25.

NAVIGATION.

NAVIGATION, in its widest sense, is generally defined as the art of conducting a ship from port to port, and may conveniently be divided into coasting and guiding the path of a vessel across the trackless ocean.

Coasting is principally pilotage, assisted by a few rules based on geometry and plane trigonometry, combined with a knowledge of that oldest and most valuable of seamen's friends, the mariner's compass. A knowledge of the compass in Europe is much older than is generally supposed. It was certainly used as far back as the beginning of the thirteenth century.

The compass plays a still more important part in deep sea navigation (with which this paper is more particularly concerned), which is so closely allied to nautical astronomy that in one sense of the word it includes it, whilst in another it distinguishes the terrestrial methods of finding the position of a ship at sea, from the more accurate methods of locating her whereabouts, that the researches and labours of the astronomer have placed at the disposal of the navigator.

The earliest efforts of the seaman, when he ventured out of sight of land, were directed by the compass, which of late years has been immeasurably improved, and by a log for measuring the rate of sailing, which has become almost as obsolete as the plane sailing and the plane chart by which he estimated his position. This method, proceeding on the assumption that the earth's surface is a plane, was fairly accurate for moderate distances near the equator, or even in higher latitudes if the vessel sailed on, or near a meridian, but was quite incapable of measuring differences of longitude, and if used, for instance, on a westerly course from Cape Clear, would produce an enormous error, if the departure or westing was taken as the difference of longitude. Owing to the uncertainty and variability of the wind, sailing vessels altered their course so often that, to save the labour of working out the difference of latitude and departure for each course and distance by trigonometry, the traverse table was introduced. It is simply the tabulated values of the sides of a number of right-angled triangles, where the hypothenuse is the distance, the perpendicular the departure, the base the difference of latitude, and the course the given angle. By means of this table it was easy to get the difference of latitude made good, by taking the difference between the sum of the northings and southings, and the departure made good, by subtracting the eastings from the westings, or *vice versâ*. This was called resolving a traverse. The inability of plane sailing to afford the difference of longitude led to the introduction of parallel sailing, middle latitude sailing, and Mercator's sailing, and the inestimable chart that bears the name of the latter. It is easily demonstrated by solid geometry, that the arc of a parallel of latitude between any two meridians is equal to the corresponding arc of the equator multiplied by the cosine of the latitude; so that if a ship sails on a parallel, it is a simple operation to convert her meridian distance or departure into difference of longitude. But a ship does not always keep to a parallel; in sailing, however, from point to point, she must leave one parallel and arrive at another. Now let the portion of the rhumb line between these two parallels be conceived to be divided into infinitely small parts, which will be sensibly straight lines on each of which is a triangle representing the corresponding difference of latitude and meridian distance. Then the departure will be the sum of all these meridian distances, and must be equal to the arc of a parallel somewhere between the two extreme ones. In middle latitude sailing it is assumed to be equal to the arc of the parallel that lies midway between the one left and that arrived at, and the difference of longitude is obtained as in parallel sailing, substituting the middle latitude for the parallel.

Though the above assumption is not strictly accurate (the real parallel always lying on the polar side of the middle latitude), the results deduced from it in favourable cases are such very close approximations as to be preferable to those obtained by Mercator's sailing, which is theoretically irreproachable.

About the middle of the sixteenth century, Gerard Mercator introduced the chart which has since borne his name, in which the meridians are all parallel and the degrees of latitude increased towards the poles, and on

which the rhumb line (or loxodromic curve which on the sphere is a spiral approaching nearer to one of the poles at every convolution) cuts every meridian that it crosses at the same angle. Mercator does not seem to have understood the principles on which his charts should be constructed, for he left no description of them, nor were they even accurate, and it was left to an Englishman, Wright, to demonstrate that, as in making the meridians parallel the meridian distances were being increased in proportion to the secant of the latitude the lengths of the degrees of latitude must be increased in the same ratio. This is obvious from the fundamental formula of parallel sailing. On this principle Wright proceeded to construct a table of meridional parts, by means of which we get a meridional difference of latitude which bears the same proportion to the difference of longitude as the true difference of latitude bears to the departure. We have then two similar triangles with the course as a common angle, either of which can be resolved by the rules of plain trigonometry. Now, whilst this method is in all cases theoretically accurate, in finding the difference of longitude in a low latitude corresponding to the distance run and the difference of latitude, if the course be near east or west, its tangent being large will rapidly multiply any error in the meridional difference of latitude (due to neglecting decimals, for the parts are generally given to the nearest whole number), and thus produce a large error in the difference of longitude, whereas the departure multiplied by the secant of the middle latitude would not be open to the same objection; besides, the course would approximate to a parallel, and so small would be the error from treating the middle latitude as such, that the result would be practically if not scientifically accurate For reasons of a similar nature the course and distance run from day to day, if sailing near a parallel, are better found by middle latitude sailing, especially in low latitudes, unless the ship crosses the equator, when the portions on each side of it ought to be obtained separately if this method be used. In all cases where the foregoing conditions do not obtain, recourse should be had to Mercator's sailing. In a doubtful case the course and distance might be calculated by both methods, and the results compared. For the purposes of steering, the course is only required to the nearest degree and, as a general rule, for computing the distance to the nearest minute. If, however, the course be near east or west, its secant, being large and changing rapidly, is required to the nearest second to obtain the distance accurately. As the seconds are of no use, except to get the secant exactly, they may be done without by observing that the required secant will exceed its tangent, which is in the computation already by the same amount as the nearest tangent in the tables is exceeded by its secant.

Except the ship is being navigated along the equator or a meridian, none of the foregoing methods give the shortest distance between two points on the globe, nor the courses to steer to attain it. This can only be accomplished by great circle sailing. A knowledge of great circle sailing is much older than is generally supposed, though it is only of late years that it, or a modification of it, has been at all generally practised, and even now it is not as much used as it ought to be. The earliest record that I have been able to find of the application to navigational purposes of a principle that must have been long known to mathematicians and astronomers, is in a work on navigation by Captain Samuell Sturmey, published in the middle of the seventeenth century, in which the gnomic chart is described. The gnomic chart is to great circle sailing what Mercator's chart is to the sailing of that name, and this old navigator gives rules how to convert a log slate into a chart on this projection so that the great circle courses can be read off with a protractor. Whilst great circle sailing can never have been forgotten, even if little practised, the gnomic chart seems to have dropped out of men's memories, for two centuries later it was rediscovered simultaneously by Mr. Godfray, of Cambridge, and Captain Bergen. Within the next few years Knorr, Hillarett, Jensen and Herrle all brought out gnomic charts more or less like Godfray's, of which Herrle's seems the best and most convenient for finding the distance as well as the course. Before, however, the gnomic charts were reinvented, Towson introduced a diagram and set of tables for facilitating great circle sailing. By means of the diagram the vertex of the required great circle is found, and then taking the successive courses and distances out of the tables is a mere matter of inspection. A few years later Deichman endeavoured to improve on Towson's diagram, and Brevoort brought out a somewhat similar diagram to accomplish the same object. Lecky has pointed out that great circle courses, within certain limits, may be taken out by inspection from Burdwood's (and other) azimuth tables, and almost without limit from his own A, B, and C tables. Lecky, too, gives short rules for computing the first course and distance. With all these methods open to the navigator, great circle sailing ought to come to the front. One of the drawbacks to it is that in the parts of the world where it would save most distance, it leads through inclement regions and amongst ice, and not the least of Towson's merits was showing how to combine it with parallel sailing so that, without going to a higher latitude than was desired, the shortest track could be followed. He finds either by calculation or his tables the two great circles passing through the points of departure and destination whose vertices just touch the limiting parallel. The vessel is navigated along the first arc till the parallel is reached, along which she is kept till the vertex of the second circle is attained when she takes the great

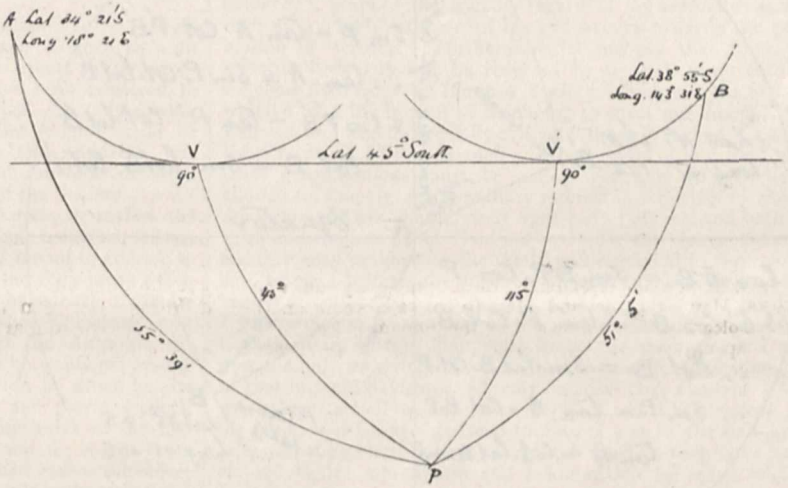


FIG. 1.—Showing the composite track from the Cape of Good Hope to Cape Otway, with 45° as maximum latitude. The composite track is from A to V, V to V', and thence to B.

Cos AV = sin lat. A, cosec lat. V. | Cos APV = tan lat. A cot lat. V.
Cos BV' = sin lat. B, cosec lat. V'. | Cos BPV' = tan lat. B cot lat. V'

APB − (APV + BPV') = VPV' which × cos 45° = VV'.

Sin A = sec lat. A, cos lat. V and sin B = sec lat. B, cos lat. V'.

circle arc to her destination. This is demonstrably the shortest distance between the two places under the given conditions.

The labour of utilising great circle sailing by the rigorous method has been much magnified. It is not necessary to find the distance accurately (or even at all) every day, and the first and last courses are easily and quickly worked with the two co-latitudes and difference of longitudes (two sides and the contained angle to find the angles at the base); and for this purpose it is near enough in practice to take out the logs to three or four figures. This is the same formula as for time azimuths, which explains why great circle courses

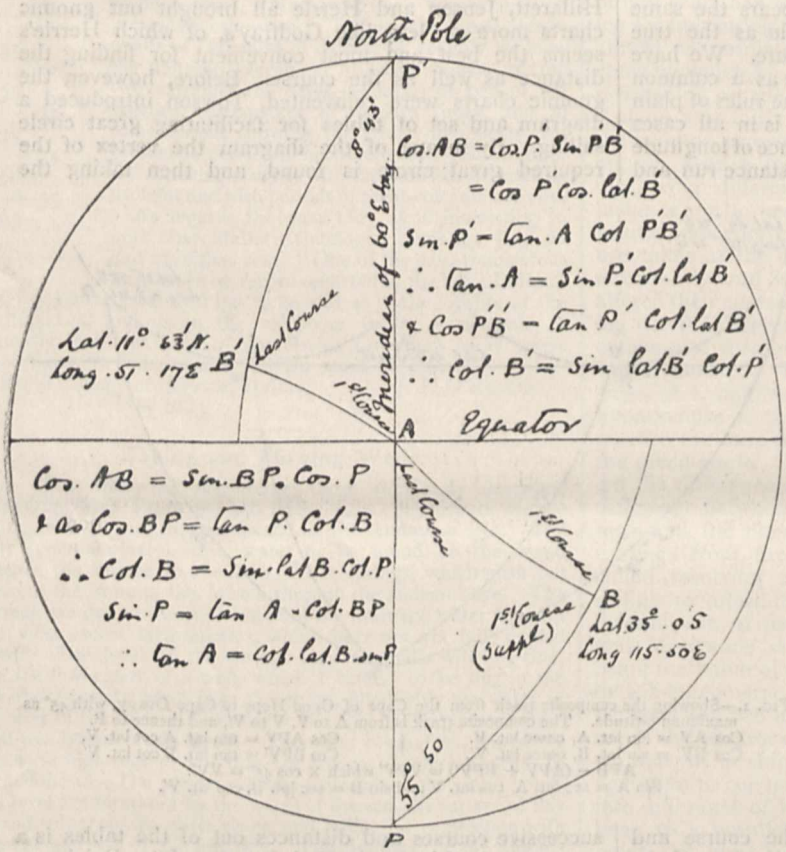


FIG. 2.

Example:

Lat. B	35° 0′	Sin 9·75859	Cos 9·91336	Cot 10·15477
D. long.	55° 50′	Cot 9·83171	Cos 9·74943	Sin 9·91772
		Cot 9·59030	Cos 9·66279	Tan 10·07249

1st course N. 68° 44′ W. AB 62° 37′ Last course N. 49° 46′ W.

60

Great circle dist. B to equator 3757 miles.

can be obtained from azimuth tables. Towson gets a right angle at the vertex, and so obtains brevity of solution. Now I will introduce a short method of my own, which I always use when the conditions are suitable. It is a very general practice to settle on the point to cross the equator according to the season of the year. Proceeding from Cape Leeuwin to Cape Guardafui, for instance, to be well to windward in the south-west monsoon, it is advisable to cross the line in about 60° E. long. Now, by working towards this point, the first course and distance may be obtained by quadrantal spherics quicker than by Mercator's sailing, because, though there are the same number of figures, the logs can be taken out in pairs, or triplets if the last course is required, to see if the ship is keeping on the same great circle. Unfortunately, it can only be used approaching the equator or in calculating a track thence to the next point of destination; but I have already shown how the courses alone can be quickly obtained in other cases, independent of the innumerable ways of getting them by inspection, and the graphic methods of Airy and Fisher, besides which there are various protractors and mechanical devices for those that favour such methods.

Now, whilst the foregoing methods are all sufficient to enable the navigator to obtain the bearing and distance of his port or destination, they are far from being irreproachable as a means of finding the daily position of a ship at sea, though they are always used for this purpose in case no better position is obtainable, or if it is, to compare with it. The cause of the deficiency is the uncertainty of the elements used in the calculation. When a ship on any given day leaves a well-ascertained point of departure, her position next day is obtained by the course steered and distance run. But neither can be absolutely relied on. In the finest vessels afloat with the most perfect navigating appliances, the course steered, even in fine weather, will be uncertain to 1°, which is equivalent to a deflection of 1¾ miles in every 100. This may easily be trebled or quadrupled in bad weather if compass errors cannot be checked, which, with every possible care, are liable to sudden and unlooked-for changes. In bad steering vessels, or with badly-placed compasses, or where the errors are not frequently checked, or from a combination of these causes, the error in the course may amount to 10°, which is equivalent to a deflection of 17½ miles in every 100. The distance run, under the most favourable circumstances, is liable to an error of 3 per cent., which head winds or other causes may easily double or, in exceptional circumstances, magnify still further. Then, again, the currents of the sea are the most uncertain element with which the navigator has to deal. Half a knot to a knot per hour is quite common, whilst five knots, or over, is not unknown. Except in a few localities, the direction is almost as uncertain as the strength. Even where currents run pretty regularly, these ocean rivers are not confined and held in position by fixed limits like those of the land, but are as flexible as snakes, which is perhaps the origin of the symbol denoting them on current charts, which at best only give a general idea what to expect: they are frequently deflected, or even reversed, by distant winds, or other causes quite beyond the ken of the navigator whose ship is being affected by them. With all these elements of uncertainty in the data used, it cannot be wondered at if the position by dead reckoning be of doubtful accuracy; and it would probably be more uncertain still, but that the numerous sources of error generally tend to compensate one another. It is, none the less, of the highest importance to the navigator to keep his log account with the greatest care, in case he has nothing better to depend on. Luckily,

however, there are more accurate methods generally available, by which the navigator can find the position of his vessel—methods approximating to those of the astronomer in his observatory, whose more refined instruments and abstruse calculations supply the seaman with the data necessary to combine with his own observations, and fix the position of his ship with all needful accuracy. In a subsequent paper I will explain how this is done.[1]

J. F. RUTHVEN.

ANNIVERSARY MEETING OF THE LINNEAN SOCIETY.

THE anniversary meeting of the Linnean Society of London, held at Burlington House on May 24, was the occasion of presentation, by its Fellows, to Sir Joseph Dalton Hooker, G.C.S.I., C.B., F.R.S., of a commemoration gold medal, in addition to that of the Society's annual gold medal, which was awarded to Surgeon-Major G. C. Wallich, M.D., the veteran naturalist of the cruise of H.M.S. *Bulldog*. In presenting the medal to Sir Joseph Hooker, the President, Dr. A. Günther, F.R.S., made the following remarks.

The completion of a monumental work in botany, the "Flora of British India," has been chosen by our Council as a fit occasion for the Linnean Society to pay its tribute to the recognition of the eminent services which have been rendered to biological science by Joseph Dalton Hooker. A gold medal, specially struck for the occasion, of which copies could be distributed among his numerous friends and admirers, was considered to be the most appropriate and the most enduring form to serve as a memorial of this desire of the Society.

If I attempted, or were competent, to pass in review the work by which J. D. Hooker has advanced botanical science and enriched its literature, the few words I intend to address to you would swell into a biography; for of the sixty years which have elapsed since he entered the service of science, there are but few in which he has not left his mark upon its history.

The four years which he passed with the Antarctic expedition, and the three years during which he wandered among the ranges of the Himalayas, were the period in which he saw nature in her most diversified, grandest and purest aspects, and was brought face to face with the mysteries of the distribution of life over the globe. Then and for many years afterwards he made these phenomena and their causes the object of his special study. His writings on the subject have had the most powerful influence on, and were the guide in all subsequent inquiries. His travels were of the highest importance, and that not with regard to our biological knowledge alone; his intimate acquaintance with geology, meteorology, his proficiency as a surveyor have rendered his accounts of the countries visited by him equally valuable to the geographer.

When biology entered upon that eventful period of its history, in which the doctrine of continuous evolution by natural selection was striving to replace that of distinct creations, Hooker was one of the foremost champions of the former. Many systematic workers in zoology and botany were apprehensive at the time of dangers arising to their methods from the new doctrine. Hooker dispelled such fears by his own example; he continued his systematic work, but he showed at the same time that it was not the end, but only the means to the end, of biological research.

The part which he took, during the lifetime of his father, and during the twenty years of his directorship, in raising the Royal Gardens at Kew to their importance and eminence, is known to all of you. But I cannot pass this short allusion to his official work without referring to the position which Kew has taken as the centre of advice and help for the kindred institutions in India and the Colonies. This bond had been already established by the father; but it was strengthened by the son's personal acquaintance with their capabilities, and his sympathy with their needs.

His official duties, sufficiently arduous by themselves, did not prevent him from obeying other demands of science, when he was called upon to perform the functions of President of the British Association in 1868, and of the Royal Society from 1873–1878. And since his retirement from the public service in 1885, at an age when most men seek for rest from their labours, we have seen him still prosecuting his work with that single-minded devotion to science which has been characteristic of the whole of his life.

The prosperity of the Linnean Society, of which he has been a Fellow since 1842, has always been to him an object of special interest. Some of his most remarkable memoirs appeared in our *Transactions*; Bentham, who devoted years of care to the welfare of the Society, was connected with him by ties of closest friendship. And last, but not least, we remember that in honouring the son we are doing homage to the memories of the father and grandfather, both of whom were illustrious Fellows of the Society.

Sir Joseph Hooker, in acknowledging the presentation, said:

Mr. President, I cannot express my sense of the great, the exceptionally great honour which your Council has conferred upon me in the founding and awarding of this beautiful medal. In receiving it, let me assure you that I value it as much for the evidence it bears of the friendly regard of my associates as for their all too high estimate of my endeavours towards the promotion of science. Furthermore, let me say that from no scientific body could it be received by me with more cordial welcome than from the Linnean Society, which was the first to which I have the honour of belonging to enrol me amongst its Fellows, and which especially cultivates those branches of knowledge to which I have devoted the best years of my life. To these considerations must be added what you yourself have alluded to, namely, my hereditary interest in a Society of which my father and grandfather were very early Fellows, and both of them contributors to its *Transactions*. To this latter circumstance it may perhaps be due that I was elected at a very early age, being, I believe, the youngest member of our body with no further scientific claims on the support of my electors than that I was serving as a naturalist in the Antarctic expedition under Captain Ross, where I happened to be the youngest, as I am now the only surviving officer of those then under the command of that intrepid navigator. I may mention that Captain Ross was himself a Fellow, and had a copy of our *Transactions* in his cabin, which was a godsend to me. I was in the Falkland Isles when my election took place, and nearly a year and a half elapsed before my captain and I knew that we were fellow Linneans.

In 1842 the Lord Bishop of Norwich was President. He was the first of ten under whom I have been privileged to sit. Had the Society adopted the rule of biennial presidents I should have sat under thirty at least, which, in my estimation, would have detracted greatly from the dignity which I attach to the chair, and I venture to think from its utility also. In the year 1842 there were 610 members of the Society (including fellows, foreign members and associates) with fully one-fourth of whom I soon became personally acquainted. Twenty-eight years afterwards, that is about midway between the former date and the present time, the number of my personal friends in the Society had risen to one-half of the whole body. Our numbers are now 820, but the proportion of my personal friends among them has inevitably shrunk from my having outlived so many associates of my middle age. And this leads me to ask your indulgence for one more egotistical detail. It is that I am perhaps the only Fellow who personally knew four of the 169 naturalists who, 110 years ago, formed the nucleus of our Society. Of these four I knew two during my later teens · they were the Rev. W. Kirby, the author, with Spence, of the "Immortal Introduction to Entomology"; and Dr. Heysham, of Carlisle, an excellent entomologist and ornithologist. The others were Aylmer Bourke Lambert, a former President, and the last, as I have been informed, who wore in the chair the presidential three-cornered hat; and Archibald Menzies, who as naturalist accompanied Vancouver in his voyage in the Pacific, and who introduced the *Araucaria imbricata* into England. These all died very near the year of my election.

Referring now to the progress of the Society in status and efficiency during the years that have elapsed since 1842, the record cannot but be gratifying to its Fellows. Of this the best proofs are the increment in extent and value of its publications,

[1] Throughout this paper the earth has been treated as a sphere. Of course it is really a spheroid with a compression of 1/300 in the polar axis. This hardly affects general principles, though it introduces slight modifications and corrections in detail. For these, and the rules of computation *in extenso*, the reader is referred to such standard and practical works as Riddle, Raper, Merrifield, Lecky, and others.

and the interest taken in its meetings. From its foundation up to the date referred to (fifty-four years) eighteen volumes of the *Transactions* in quarto had been published. During the succeeding fifty-four years about double that amount have been produced in the same form, besides fifty-eight volumes of the *Journal* in octavo, which latter was not commenced till 1857.

Then as regards attendance at the meetings during the first years of my fellowship, it was miserably small. If my memory does not deceive me, I recall a night in Soho Square when only five Fellows supported the President and Secretary. There was a dearth of papers too, and the discussion of such as were brought forward was discountenanced by the chair. All this is now happily a thing of the past, and I should not have alluded to those bad times had not the Society given proof of that inherent vitality which supported it under a temporary depression, and subsequently raised it to its present position.

It remains, sir, to thank you cordially for coupling my father's name with my own in this award, but for which, indeed, I could not have accepted it without a protest. I inherited from him my love of knowledge for its own sake, but this would have availed me little were it not for the guiding hand of one who had himself attained scientific eminence; who by example, precept and encouragement kept me to the paths which I should follow; launched me in the fields of exploration and research, liberally aided me during his lifetime, and paved for me the way to the position he so long held at Kew with so great credit to himself, and benefit especially to our Indian and Colonial possessions.

The gold medal of the Linnean Society was received on behalf of Surgeon-Major Wallich by his son, and, in presenting it, Dr. Günther spoke as follows:—

The gold medal of the Society is awarded this year to a zoologist, to Dr. George Charles Wallich. Although Dr. Wallich's scientific work commenced some years before, it was the year 1860 in which he entered upon the line of inquiry with which his name will be ever associated. On the recommendation of Sir Roderick Murchison and Prof. Huxley he was attached in that year as naturalist to H.M.S. *Bulldog*, on her voyage across the Atlantic to survey the sea bottom for the laying of the proposed Atlantic cable. The materials obtained by the sounding operations were slender; but in working them out, Dr. Wallich showed that he had already grasped all the principal problems of deep-sea research. To the solution of these problems he applied his wide range of knowledge, the soundness and power of his reasoning, his originality and independence of thought. His work, "The North Atlantic Sea-Bed," incomplete as it is, stands as a lasting record of the progress made by him in our knowledge of deep-sea life, and of the impetus which he gave to subsequent deep-sea exploration.

For more than twenty years he continued to work in the same line of inquiry, and in investigating collateral subjects, notably the life-history, structure and relationships of those unicellular organisms which play so important a part in pelagic and bathybial life, the lithological identity of the ancient chalk formation, and of the calcareous deposits in the oceans of the present time.

The remarkable results which he obtained in his investigations were due not only to his accuracy and keenness as an observer, but also to the ingenuity of the methods applied by him. Thus at a time when our modern micro-chemical methods were unknown, he employed the electric discharge as a means of differentiating the nucleus, and he determined the excretory function of the contractile vacuole.

Your Council were of opinion that work of such originality, advancing so many branches of biology, was peculiarly fit to be honoured by the award of the Linnean medal.

NOTES.

WE notice with deep regret the announcement that Lord Playfair died on Sunday. The funeral will take place on Saturday at St. Andrews, Fifeshire.

WE are requested to state that the Chemical Society's banquet to the past presidents on June 9, and also Dr. Mond's garden party on June 10, are postponed in consequence of the death of Lord Playfair, the senior past president and the last surviving founder of the Society.

THE Ladies Soirée of the Royal Society will take place next Wednesday, June 8.

SIR WILLIAM H. FLOWER, K.C.B., has received, from the German Emperor, the Royal Prussian order "Pour le Mérite" for Science and Art.

THE death is announced of Prof. F. Müller, distinguished for his works on ethnology and philology.

PROF. G. H. DARWIN, F.R.S., has been elected a foreign honorary member of the American Academy of Arts and Sciences, in succession to the late Prof. J. J. Sylvester.

AN exhibition of specimens of practical work of candidates at the technological examinations of the City and Guilds of London Institute will be opened at the Imperial Institute next Thursday, June 9, by the Right Hon. Lord Herschell.

THE Albert Medal of the Society of Arts for the present year has been awarded, with the approval of the Prince of Wales, the President of the Society, to Prof. Robert Wilhelm Bunsen, Foreign Member of the Royal Society, "in recognition of his numerous and most valuable applications of chemistry and physics to the arts and to manufactures."

INFORMATION of the death of Mr. W. M. Maskell, Registrar of the University of New Zealand, has been received by the *Entomologist's Monthly Magazine*. Mr. Maskell was well known for his researches in *Coccidæ*; he also published papers on *Aleurodidæ* and *Psyllidæ* amongst insects, and on Desmids in microscopic botany. The majority of his papers have appeared in the *Transactions* of the New Zealand Institute, the first having been published in 1879. At first he restricted himself to the species found in New Zealand, but later on those of Australia (especially the curious gall-making *Brachyscelidæ*), Asia, &c., came under his notice, he having become a recognised authority on the subject of *Coccidæ*. He usually published at least one paper a year in New Zealand, the later ones being lengthy, and all copiously illustrated by his own drawings.

THE Berlin correspondent of the *Times* announces that the German steamship *Helgoland* has just started on an expedition to the North Pole. The ship is built entirely of steel. She carries on board provisions for thirteen months and four boats, two of which she picks up at Tromsö. Special care has been taken in the selection of her crew, some eleven in all. The leader of the expedition, Herr Theodor Lerner, is accompanied by Dr. Brühl, Dr. Römer, and Dr. Schaudien, who are all experienced travellers and men of science. Two other expeditions—both of American origin—are about to set out with the object of reaching the North Pole. Lieut. Peary will attempt the Pole from North Greenland, while Mr. Walter Wellman will make the effort from Franz Josef Land. Mr. Wellman is now in London, and will leave in a few days for Tromsö, Norway, where his ice steamer, the *Frithyof*, is ready for him, and whence she will sail in about three weeks for the Far North. In his party are Prof. James H. Gore, of Columbia University, who will make gravity determinations in Franz Josef Land; Lieut. Evelyn B. Baldwin, of the United States Weather Bureau, who was on the Greenland ice cap with Lieut. Peary, and who is an accomplished meteorologist and geologist; Dr. Edward Hofma, of the University of Michigan, naturalist and medical officer; and Mr. Quirof Harlan, physicist from the United States Coast and Geodetic Survey, a Norwegian experienced in Arctic work.

THE Home Secretary has appointed Dr. Oliver, of Newcastle-upon-Tyne, and Dr. T. E. Thorpe, F.R.S., Government Analyst, as experts to proceed to the Potteries for the purpose of inquiring

into the various kinds of glazes in use there, and as to whether any substitutes can be found for those containing lead. Not only will the work undertaken by these gentlemen have a humane bearing and be of a scientific nature; it will be helpful also to the manufacturers. This is the first instance (says the *British Medical Journal*) in which the British Government has called to its aid expert help, not only to assist it in framing regulations for the health of the workers, but also of helping on industries. As the manufacturers are sure to co-operate heartily with those to whom has been entrusted this important special inquiry, it is to be hoped that results will be arrived at which will remove from one of our prosperous and oldest industries the stain that has so long lain upon it.

DR. AGAMENNONE, who has paid considerable attention to the velocity of earthquake-waves, has recently published a valuable paper on the mean surface-velocity of the pulsations from the great Calcutta earthquake of last June 12 (*Rend. della R. Accad. dei Lincei*, vol. viii., 1898, pp. 265–271). Relying on accounts which have already appeared in NATURE, he assumes the centre of disturbance to be in 25° N. lat. and 91° E. long. At Calcutta, which is 400 km. from this point, the time of occurrence was 11h. 4·6m. a.m. (Greenwich mean time) according to Mr. La Touche; and 11h. 7m. according to Mr. Oldham. The earthquake was registered by seismographs and magnetographs at nineteen observatories in Europe, the most distant being Edinburgh, 7970 km. from the epicentre. Excluding the record on the Parc St. Maur magnetograms, which differs considerably from the others, the mean surface-velocity of the earliest vibrations was either 9 or 11 km. per second, according to the time taken for Calcutta. These first rapid vibrations lasted for about 23 minutes, and were succeeded by large long-period oscillations, the mean surface-velocity of which was either 2·61 or 2·76 km. per second. At Rome, the period of these oscillations was about 10 seconds, and their maximum amplitude 12″. Thus, as it crossed Italy, the complete wave must have been 54 km. in length, and the height of its crest about half a metre.

SENOR ANTONIO BLAZQUEZ communicates to the *Boletino* of the Madrid Geographical Society a preliminary paper on a fresh investigation as to the precise length of the Roman mile. The question has been a constant source of difficulty in connection with the determination of the sites of ancient cities, and the tracing of former inhabitants of the peninsula, and a great deal of evidence is discussed which goes to show that the Roman and the Arab miles were of the same length: 1672 metres. The length formerly accepted was 1481 metres. The detailed investigation is promised in a future paper.

DR. C. DAMMANN adds another to the already numerous monographs on German rivers in a paper on the Wupper, published in the *Verhandlungen des naturhistorischen Vereins der preussischen Rheinlande*. A careful study is made of the geology and geomorphology of the river and its basin, and of the rainfall and drainage. The fact that the basin of the Wupper consists almost entirely of impermeable rocks, gives the sudden variations in the volume of the stream some special features, especially with regard to floods. Some idea of the rapidity of these changes is given by the record of the rate of discharge on three successive days: 52·7, 182·3, and 51·7 cubic metres per second.

IN Darwin's geological observations on the volcanic islands visited during the voyage of H.M.S. *Beagle*, reference is made to a "volcanic bomb" found in the interior of Australia. The specimen was composed of green obsidian, and was found on a great sandy plain between the rivers Darling and Murray, at a distance of several hundred miles from any known volcanic region. Many similar specimens of obsidian "buttons" have since been found in Australia, and the *Proceedings* of the Royal Society of Tasmania (1897) contains two short descriptive papers on their occurrence in Tasmania. How these singular objects found their way to some of the localities in Tasmania, where their occurrence in undisturbed quartz drift far away from any known volcanic source has been reported, is unexplained. That they are volcanic products is unquestionable; and their spheroidal or discoid form points to rotation while in a fluid state. It has been suggested that the objects came from lunar volcanoes, but it is highly improbable (even if they were ejected from the moon) that they would reach our globe, and if they did they could not penetrate the atmosphere. Mr. T. Stephens, the author of one of the papers referred to, thinks the aborigines of Australia are probably largely responsible for the distribution of the obsidian buttons over the mud-plains of Victoria and Riverina, but no such explanation can be given in reference to most of the places where they have been found in Tasmania. In a paper by Messrs. W. H. Twelvetrees and W. F. Petterd in the *Proceedings* mentioned above, the suggestion is made that the objects are products of terrestrial volcanoes of an acid or sub-acid type, formerly in eruption in the southern hemisphere. The nearest known source of tertiary obsidian is New Zealand, but whether the objects have been transported through the air from that island, or from the Antarctic continent or elsewhere, it is impossible at present to decide.

WE learn from the *Meteorologische Zeitschrift* for April that Signor Boffito, librarian of the Moncalieri Observatory, near Turin, intends to publish a repertorium of Italian meteorology, which, like the valuable repertorium of German meteorology published by Dr. Hellmann in 1883, will contain a practically complete bibliography of meteorological works written in the Italian language. As the meteorological literature of Italy was especially rich in the fifteenth and sixteenth centuries, the publication of the proposed work will be very welcome. Signor Boffito will be glad to receive notice of any works published in the Italian language in other countries.

IN the U.S. *Monthly Weather Review* for February an interesting account is given of the value of a searchlight for making weather signals known in large cities or seaports at an hour of the evening when it is too late to give warning by the usual method. In the month of February 1895, the searchlight for the unfortunate battleship *Maine*, then nearing completion, was lent for temporary use at the Chicago office of the Weather Bureau, and the experiments were conducted by the present chief of the latter institution. From observers and other persons it was ascertained that the signals were clearly seen at a distance of twenty miles. At present the great cost of maintaining the apparatus in operation would preclude its adoption, but in the event of the expense being eventually reduced, the author thinks it might be used by the Weather Bureau for the purpose of immediately disseminating forecasts made from the evening observations.

THE relative merits of the weather predictions issued daily by the U.S. Weather Bureau for one or two days in advance, and those published by "farmer's almanacs" a year or more in advance, were lately made the subject of newspaper paragraphs in America, and are commented upon by Prof. Cleveland Abbe in the *Monthly Weather Review*. Of course, no true comparison can be made between the results; for while the predictions made by the Weather Bureau are based upon actual observations of atmospheric conditions, the popular weather prophets depend chiefly upon inspiration and astrological combinations, though some do go so far as compile from the records of past years a table showing what sort of weather has prevailed most frequently on the respective days of the year, and use this table for

predicting the weather of future years. The art of almanac preparation, however, is in the free use of a system of general terms which will apply just as well to a thunderstorm, a hurricane, or an earthquake. The warning "look out for something very unusual about this time," is a meteorological prediction of this character.

FOR the benefit of those who make a comparison between the prophesies of the almanac-maker and the forecasts of the U.S. Weather Bureau, Prof. Abbe delivers the following homily:—In connection with meteorology in general, and especially weather predictions, there is a popular tendency to make a mistaken use of the word "science." Knowledge is science as distinguished from the world of imagination, which is fiction. Whatever is logical and true may be called scientific, but whatever is illogical or untrue is certainly not scientific. A map or a survey that gives us an exact picture of the true location of every spot on the earth's surface responds to scientific geography. A catalogue of all the plants and animals on the earth or of the stars in the sky constitutes a biological or an astronomical survey, and is truly scientific. A series of maps of the weather at 8 a.m. daily is a scientific meteorological work, and any predictions of the weather that can be logically deduced from these maps is a scientific prediction. But a lot of predictions that are said to be deduced in defiance of sound logic and with a very imperfect knowledge of the laws of nature are fanciful fictions and not scientific, because they are contrary to all sound knowledge.

IT is well known that the Kea or Mountain Parrot of New Zealand has acquired the habit of attacking sheep, and making holes by means of its sharp and powerful beak in the backs of these animals for the purpose of abstracting the kidney fat, which appears to be esteemed as a luxurious diet. It is supposed that this peculiar habit or instinct was developed by the bird getting the fat from the skins of sheep that had been slaughtered; but this solution is not very satisfactory, as there appears nothing to connect the fat on the skins of sheep with the live animals. In a note published in the *Zoologist* (May 16), Mr. F. R. Godfrey, writing from Melbourne, offers the following solution of the mystery, which seems to him to be simple and satisfactory, and more rational than the sheep-skin theory. In the hilly districts of the Middle Island of New Zealand there is a great abundance of a white moss or lichen, which exactly resembles a lump of white wool, at the roots of which are found small white fatty substances, supposed by some to be the seeds of the plant, and by others to be a grub or maggot which infest it, which is the favourite food of the Kea. Probably the bird, misled by this resemblance, commenced an exploration in sheep, and this proving satisfactory, originated the new habit. In a note to this suggestion, the editor points out that Mr. Godfrey is in agreement with Mr. F. R. Chapman (New Zealand *Journal of Science*, 1891), who, describing a valley of the Upper Waimakariri, Canterbury, says: "A very interesting *Raoulia*, or vegetable sheep, was very plentiful on steep, rocky places; but I believe a finer species is found on Mount Torlesse. . . . It is said that the Keas tear them up with their powerful beaks, and that these birds learnt to eat mutton through mistaking dead sheep for masses of *Raoulia*."

As the British Patent Law at present stands, foreign inventors can obtain patents in this country without "working" their invention, and they take the fullest advantage of this state of affairs. To give an instance: in the five years from 1891 to 1895 no less than six hundred patents were granted to foreigners for coal-tar products, not a single one of which is being worked in this country. The object of Section 22 of the Patents, Designs, and Trade Marks Act (1883) was to ensure the working in the British Isles of inventions for which the privilege of British registration has been granted, either by the patentee or by others. In order to secure this object, the Section confers upon the Board of Trade authority to order the granting of licenses on equitable terms. Unfortunately, although the Act has been in force for fifteen years, this authority has never been used, because the prosecution of a petition for the exercise of such authority involves what is practically a very costly legal contest at the expense of the petitioner. Upon the invitation of the Board of Trade, a petition has at last been carried through with the approval of the Manchester Chamber of Commerce. The facts and issue of the prosecution of it are set forth in a pamphlet prepared by the Chamber, and they need only be read to understand that British trade and industry is seriously prejudiced by the present unsatisfactory state of the Patent Law. In France, if a patent is not worked within two years (and the patentee has to prove that it *is* worked), the patent is revoked, and is declared void. In Germany the law is similar, with this exception—that the patentee, instead of two, has three years' time within which to work his invention. What is wanted is a short amending Act which will bring our Patent Law in conformity with those of Germany and France; and it is with the object of calling attention to the need of such a provision that the Manchester Chamber of Commerce has placed the whole facts before the public.

A NUMBER of examples of *Abraxas grossulariata*, in which the markings of the fore-wings, which are usually of a bright yellow, were of a deep dull ochreous colour, were exhibited at a meeting of the South London Entomological and Natural History Society at the end of last year (*Proceedings* for 1897). The specimens were sent by the Rev. J. Greene, of Clifton, Bristol, who reared them from larvæ found on the shrubs of Euonymus, which appears to be their favourite food. During the past six years Mr. Greene has bred a large number of these insects under precisely the same conditions as regards food, temperature, light and darkness. The insects were kept indoors both as larvæ and pupæ, so wet and dry weather could apparently have no effect upon them; and they were all collected within a two-mile radius, where there was no difference of soil. And yet, under these uniform conditions, Mr. Greene produced at least two hundred and fifty varieties. A remarkable variation was noticed in the "contour" of the specimens—that is, in the length, breadth, and curvature of the upper wings; but it is difficult to determine the causes which can produce such a change in the form and shape of the wings. In Mr. Greene's opinion there is one, and one only method by which entomologists may reasonably hope to obtain varieties, namely, by "crossing" the imagines, dark with light, &c. He considers this to be the true cause of the varieties of *grossulariata* obtained by him.

THE drinking habits of some butterflies and moths are briefly described by Mr. J. W. Tutt in a paper published in the *Proceedings* of the South London Entomological and Natural History Society, 1897. A number of observations are cited showing that the drinking of large quantities of water by certain species is beyond question. Mr. Tutt concludes as follows:—"That they drink infinitely more than is required by their tissues under any possible conditions appears certain. Baron's note (NATURE, vol. xxviii. page 55, May 17, 1883) is sufficient proof of this; whilst we have known *Polyommatus damon* to sit for more than an hour motionless, except for the slight movements of sucking up and discharging the moisture almost continuously. What this internal bath may really mean we cannot even surmise. Another important factor as to this drinking habit is a strange one; the 'thirsty souls' are, so far as my own observation goes, and so far as De Nicéville's and Bates' remarks show, almost entirely males. Why is this drinking habit con-

fined to one sex, and why is it indulged in whilst the females are away egg-laying, or presenting the strange phenomenon of a perfectly different habit from that indulged in by their lords and masters? It is of course quite reasonable to suppose that, if a number of exact observations be made, females in small numbers do visit puddles, and pools, and streams for drinking purposes. Certain it is that females come to sugar equally with males, but this we may take it is for food, and not for drink, and it is just in this that our difficulty lies. We know that moths and butterflies that visit sugar, over-ripe fruit, and similar dainties are of both sexes. They come, it seems, for food; but males alone seem to be attracted by pure water. Does their extra activity give them a greater need in this direction? and has a habit which was at first (and still is in a measure) a necessity become so pleasurable that excessive drinking has literally become a vice?"

MESSRS. SEELEY AND CO. will shortly publish a concise popular account of wireless telegraphy, by Mr. Richard Kerr, being the substance of lectures delivered by him in the principal cities of England, Scotland, and Holland. Mr. Preece will contribute a preface to the volume.

HERREN FEIEDLÄNDER, of Berlin, have just issued their Book-Catalogue No. 430, consisting of 103 pages, entirely devoted to the anatomy, physiology, and embryology of plants.

AN earnest appeal is made by the Rev. W. Porter, "Von-mueller," Arnold Street, South Yarra, Victoria, one of the trustees, for further contributions for the erection of a granite monument over the grave of the late Baron Ferdinand von Mueller, in the cemetery of St. Kilda.

DR. ERWIN F. SMITH reprints a lecture delivered before the Massachusetts Horticultural Society on the spread of plant diseases, in which he discusses the parts played respectively by insects and by the wind in the propagation of the diseases of plants.

THE May number of the *National Geographic Magazine* is devoted to an account of the geography, resources, and political conditions of Cuba, and contains as a frontispiece the portrait of Captain Charles D. Sigsbee, the commander of the ill-fated battleship *Maine*. For several years, prior to taking command of the *Maine*, Captain Sigsbee was Hydrographer of the Navy Department, and his contributions to our knowledge of the sea bottom, and its topography, place him in the front rank of scientific hydrographers.

MESSRS. TAYLOR, TAYLOR, AND HOBSON have issued a booklet of twenty-three pages setting forth the merits of their Cooke lens. Every photographer knows how difficult it is to obtain a lens which gives a sharply-defined image all over the field of view. By increasing the number of lenses, it is possible to overcome this difficulty and secure sharp definition even at the margins of a picture. The Cooke combination satisfies this photographic desideratum by the simplest means, only three lenses being used in its construction. The superiority of the lens over the symmetrical and other old types is strikingly shown in the book by a series of reproductions from the margins of plates.

THE eleventh part of Mr. Oswin A. J. Lee's illustrated work "Among British Birds in their Nesting Haunts" has been published by Mr. David Douglas, Edinburgh. Ten plates are included in this new part, representing nests of the robin, wren, rook, marsh tit, golden eagle, spotted flycatcher, teal, and pheasant. An insertion announces that the author is desirous of taking photographs of the nests of the following birds: kite, Montagu's harrier, honey buzzard, hobby, garganey, and ruff. If any reader is able to help Mr. Lee to procure these, intimation should be sent to him at 58 Manor Place, Edinburgh.

"WE have the satisfaction of being able again to look back upon a year of general activity and extended progress, which will bear comparison with any of its predecessors." The Report of the Marlborough College Natural History Society, from which these words have been taken, show that interest in scientific subjects is well fostered by the Society. The members are encouraged to observe and to contribute papers recording the results of their observation and reading, so that the Society, like other similar societies in our public schools, is of great assistance in developing very useful faculties. For instance, the following observation, by "E. A. M.," of climbing habit in frogs is interesting:—"Some frogs have taken up their abode for the last month in two deserted blackbirds' nests, built in round thick box bushes, about two feet from the ground. One frog is generally to be seen alone sometimes on or near the edge of the nest, sometimes comfortably ensconced in the middle, only his head peeping out. In the other nest there are now always two frogs." Mr. E. Meyrick describes and figures some cinerary urns discovered during excavations in the College grounds.

THE additions to the Zoological Society's Gardens during the past week include a Collared Peccary (*Dicotyles tajaçu*) from South America, presented by Mr. Eustace Grey; a Gazelle (*Gazella dorcas*, ♂) from North Africa, presented by Mr. J. D. Lambert; a Short-headed Phalanger (*Petaurus breviceps*) from Australia, presented by Mr. Julian T. Pym; a Small Hill Mynah (*Gracula religiosa*) from India, presented by Mrs. Strather; a —— Squirrel (*Sciurus*, sp. inc.), three Schlegel's Doves (*Calopelia puella*) from West Africa, presented by Mr. W. H. Boyle; two Malabar Squirrels (*Sciurus maximus*, var. *dealbatus*) from India, presented by Mr. R. C. Wroughton; an Algerian Tortoise (*Testudo ibera*) from North Africa, presented by Mr. Albert West; a Smooth Snake (*Coronella austriaca*), British, presented by Mr. Bryan Hook; a Black-shouldered Kite (*Elanus cæruleus*), a Tachiro Goshawk (*Astur tachiro*), a Spotted Eagle Owl (*Bubo maculosus*), two Infernal Snakes (*Boodon infernalis*), two Lineated Snakes (*Boodon lineatus*), a Smooth-bellied Snake (*Homalosoma lutrix*), four Rough-keeled Snakes (*Dasypeltis scabra*), eleven Rufescent Snakes (*Leptodira hotambœia*), four Rhomb-marked Snakes (*Trimerorhinus rhombeatus*), fifteen Crossed Snakes (*Psammophis crucifer*), a Cape Adder (*Bitis atropos*), three Puff Adders (*Bitis arietans*) from South Africa, presented by Mr. J. E. Matcham; a Gazelle (*Gazella*, sp. inc., ♂) from Senegal, two Black-striped Wallabies (*Macropus dorsalis*, ♂ ♀) from New South Wales, a Canadian Skunk (*Mephitis mephitica*), a Florida Tortoise (*Testudo polyphemus*) from North America, a Beccari's Cassowary (*Casuarius beccarii*) from New Guinea, a Sharp-nosed Crocodile (*Crocodilus acutus*) from Jamaica, deposited; two Mantchurian Cranes (*Grus japonensis*) from North China, purchased; an African Wild Ass (*Equus tæniopus*, ♂), two Barbary Wild Sheep (*Ovis tragelaphus*), two Black-necked Swans (*Cygnus nigricollis*), bred in the Gardens.

OUR ASTRONOMICAL COLUMN.

SUN WORSHIP BY TUSAYAN INDIANS.—In the fifteenth annual report of the U.S. Bureau of Ethnology, and in recent numbers of the *American Anthropologist*, Dr. J. Walter Fewkes gives a detailed account of a group of the ceremonials which form the ritual practised by the Tusayan Indians. It has been known for some years that the aborigines of the semi-deserts in the south-western portion of the United States possess a remarkably elaborate system of belief and ceremonial, and Dr. Fewkes has devoted a considerable amount of attention to them in order to determine the significance of the various parts of the ritual followed. In the course of his investigations he has made a number of interesting observations on the astronomical means used for determining the time for ceremonials. He has found

that among the Hopi Indians there are priests skilled in the lore of the sun, who determine, by observation of the points on the horizon where the sun rises or sets, the time of the year proper for their religious observances. An important ceremony is performed at the winter solstice, and in December 1897 Dr. Fewkes made a special journey to Arizona to study the ritual on the spot. This is not the place to refer to the ethnological aspects of the ceremonials witnessed by him, but the following extract from the Report of the U.S. Bureau of Ethnology will interest students of primitive astronomy.

"We are justified in accepting the theory that sun and moon worship is usual among primitive men. Whether that of the sun or of our satellite was the earlier, it is not in the province of this article to discuss, but it is doubtless true that sun worship is a very ancient cult among most primitive peoples. The Pueblos are not exceptions, and while we cannot say that their adoration is limited to the sun, it forms an essential element of their ritual, while their anhydrous environment has led them into a rain-cloud worship and other complexities. I think we can safely say, however, that the germ of their astronomy sprang from observations of the sun; and while yet in a most primitive condition they noticed the fact that this celestial body did not always rise or set at the same points on the horizon. The connection between these facts and the seasons of the year must have been noted early in their history and have led to orientation, which plays such an important part in all their rituals. Thus the approach of the sun to a more vertical position in the sky in summer and its recession in winter led to the association of time when the earth yielded them their crops with its approach, and the time when the earth was barren with its recession. These epochs were noticed, however, not by the position of the sun at midday, but at risings and settings, or the horizon points. The two great epochs, summer and winter, were, it is believed, connected with solstitial amplitudes, and the equinoctial, horizontal points, unconnected with important times to agriculturists, were not considered as of much worth. There is every evidence, however, that the time of day was early indicated by the altitude of the sun, although the connection of the altitude at midday with the time of year was subordinated to observations on the horizon."

STELLAR RADIATIONS.—Referring again to the problem of the measurement of stellar radiations, mentioned in our issue of May 12 (p. 39), the recent improvement in galvanometers ought to help the matter towards solution. At the meeting of the Physical Society on May 13, Prof. Ayrton said that the sensitiveness of these instruments had increased during the last few years in the ratio of 27 to 3,310,000. Of course it must be remembered that these figures apply to a particular class of instrument, and that they are based upon a somewhat empirical definition of the factor of sensitiveness. Nevertheless, they do indicate advance in the refinements of current-measurement.

It is to be hoped that similar attention may now be given to perfecting an electrometer for extremely small potential-differences; such an instrument is required for the development of photo-electricity generally. The sensitive plates of the cells used by Prof. Minchin for stellar measurement are only a few square millimetres in area; the advantage of this is that several of them can be placed together at the focus of a telescope. Their function is, not to give current, but potential differences when exposed to light. They respond chiefly to yellow radiations, and each plate, irrespective of its size, gives from one-third to one-half a volt, for daylight. If electrometers could be improved in the ratio 27 to 3,310,000, the experiments made by Pouillet, just fifty years ago, might be extended almost to the circumjovial planets.

THE LATE PROF. SOUILLART.—At the meeting of the Paris Academy of Sciences on May 23, M. Callandreau gave a short account of the late Prof. Souillart, whose death we have already announced. Prof. Souillart was elected a Correspondant of the Academy in succession to M. Gyldén, the Academy thus showing its esteem for the astronomer who during thirty years devoted his leisure to the study of the theory of the satellites of Jupiter, and succeeded in bringing out important complements of the chief work of Laplace. It was while studying under M. Puiseux, at the Normal School, that M. Souillart had his inclination turned to celestial mechanics. In 1865 his "Essai sur la théorie analytique des satellites de Jupiter" appeared in the *Annals* of the School, and formed the basis of two later memoirs —one, published by the Royal Astronomical Society, devoted to the analytical theory of the movements of the satellites; while the other, dealing with the reduction of the formulæ to numbers, appeared in the thirtieth volume of the "Mémoires des Savants étrangers." In addition to these publications, a series of notes appeared in the tenth, eleventh, and twelfth volumes of the *Bulletin astronomique*. The whole of these works formed the basis of the treatment of the satellites of Jupiter given by M. Tisserand in his "Traité de Mécanique céleste."

When M. Souillart left the Normal School he was appointed professor of mathematics in the Saint-Omer High School, and at the same time was attached to the Faculty of Sciences at Nancy. In 1873 he became professor of mécanique rationelle at Lille University, and, some years later, professor of astronomy, which post he occupied at the time of his death.

THE INDUSTRIAL APPLICATIONS OF ELECTRO-CHEMISTRY.

THAT electricity is able to bring about chemical change appears to have been observed for the first time about the middle of last century. With Volta's discovery of the principle of his pile, in 1792, it became possible to set larger quantities of electricity in motion, and in 1800, the year in which Volta described his first large battery, the study of the chemical effects of the electric current may be said to have commenced with the observations of Nicholson and Carlisle on the electrolysis of water. They were the first to notice the separate evolution of the products of the decomposition at opposite poles; so that our knowledge of electrolysis, upon which the majority of the applications of electro-chemistry depend, may be said to have been acquired in the nineteenth century.

In the early 'thirties it was repeatedly proposed to deposit metals by immersing the object to be coated in a solution of the metal, placing it in contact with a more oxidisable metal. An external source of current was applied to electrotyping in 1839 by Jakobi, Spencer and Jordan independently of each other; the first-named also describes the employment of electrolytic gas in producing lime-light. The use of a current generated by magneto-electric machines was patented in 1842, and, according to Mr. Swan, current generated in this way was employed by Messrs. Elkington at Birmingham in that year. It was not, however, until 1864-5 that the more perfect machines of Pacinotti and Wilde made it possible to produce the electric current at a sufficiently economical rate to permit of its employment in a chemical process on the manufacturing scale. The electrolytic refining of copper was patented by Mr. J. Elkington in 1865 and 1869, and in the latter year the first electrolytic copper refinery was erected at Pembrey, near Swansea. The progress of electro-chemical industry was at first slow, but the improvements in dynamos and steam-engines, stimulated by the rapid extension of the applications of electricity to lighting and other purposes, the development of water powers, and last, but not least, the impetus given to the study of electro-chemistry by the theories of Van 't Hoff and Arrhenius, have contributed to make this progress during the past decade extraordinarily rapid. A circumstance, the effect of which on the future development of the applications of electro-chemistry is not to be underrated, is the evolution of a new type of chemist—one, namely, who adds to his knowledge of chemistry a competent knowledge of physics and especially of electricity; there can be no doubt that the country in which the facilities for obtaining training of this kind are defective will be heavily handicapped in the future. With special electro-chemical laboratories being founded at almost every university and polytechnic in Germany, it is depressing to see so little being done in our own country (more especially since it is apparently becoming increasingly difficult for foreigners to obtain admission to the German laboratories).

The present position of technical electro-chemistry has not been attained without many failures; instructive and interesting as many of these are, it is impossible to refer to them within the limits of this article, which must, therefore be confined to a general description of processes actually employed.

The oldest and most important of these is the electrolytic copper-refining process. The copper containing 0·3 to 2 per cent., or sometimes more, impurity is cast into plates which are suspended, some 3 or 4 inches apart, in large, lead-lined wooden boxes. Between each pair of plates a thin sheet of pure copper is suspended, and the solution, containing 15 to 20 per

cent. of crystallised copper sulphate and 5 to 6 per cent. of sulphuric acid, run in. The impure copper plates, of course, form the soluble anodes, the thin sheets receiving the deposit of pure copper. A current of from 100 to 200 amperes per square metre is usually employed, the E.M.F. being 0·2 to 0·4 volt. The electrical energy needed is, therefore, 0·1 to 0·2 electrical horse-power hour per pound of copper deposited. Considerable variations in the details of working are found in different works, owing to the varying local conditions. When a larger current density is employed the amount of electric energy required to deposit a pound of copper is greater, but, on the other hand, the copper is deposited more quickly, and therefore, for a given output, less copper is locked up in the baths, less labour is required, and a smaller plant is sufficient. In order to obtain a homogeneous deposit of copper the solution must be kept in circulation, otherwise a deficiency of copper near the kathode surface would arise, which would lead to the formation of a non-coherent impure deposit. Of the impurities in the anodes, gold, silver, and part of the arsenic and antimony remain undissolved, whilst iron, nickel, and the remainder of the arsenic and antimony pass into solution. The two latter metals are deposited along with the copper if they are allowed to accumulate too largely in the solution, especially if the amount of free acid present is small. The solutions must therefore be purified from time to time, and this forms the main difficulty of the process. By blowing air through the solution, after neutralising it with cupric oxide, ferric arsenate and basic antimony sulphate are deposited; but large quantities of copper sulphate are thus accumulated, which are difficult to dispose of. Where cheap power is available, the impure solutions may be electrolysed with insoluble anodes of lead and the copper, arsenic and antimony deposited; otherwise evaporation and recrystallisation must be resorted to.

The anode slimes which contain Au, Ag, Se, Te, Bi, Sb, and As, are worked up to recover the precious metals. In 1896, 137,000 tons of electrolytic copper were obtained, of which the United States produced more than all other countries together. The greater part of this pure copper is employed for electrical purposes, where its high conductivity is of paramount importance. The electrolytic copper is obtained in a coarsely crystalline condition, and is fused before use. Mr. Elmore aims at depositing the copper directly in the form in which it is to be employed; copper tubes, for example, are made by depositing the metal upon a rotating cylinder, the surface of the deposit being constantly polished by a prismatic piece of agate which moves backwards and forwards parallel to the axis of the cylinder. This produces a very dense and tough deposit, and at the same time permits of the employment of a current density as high as 600 amperes per square metre. The removal of the cylinder from the tube is very simple when it is made of some easily fusible alloy.

The electrolytic process for making aluminium has entirely superseded the chemical process, the superiority of the former (from a commercial point of view) being demonstrated by the diminution in the price of aluminium from over 20*s.* per lb. in 1888 to about 1*s.* 4*d.* to-day. The electrolyte employed is a solution of alumina in a fused mixture of the fluorides of aluminium and of the alkali or earth-alkali metals. Minet has used a mixture of common salt and aluminium fluoride, but it would appear that the solvent usually employed is cryolite from which iron and silicon have been removed by a preliminary electrolysis. The baths consist of large iron, carbon-lined boxes, the lining forming the kathode. The anode consists of massive blocks of carbon suspended above the bath, and dipping under the fused electrolyte almost to the bottom of the bath. The electrolyte is maintained in the fused state by the heat generated by the passage of the current, and the aluminium collecting on the bottom of the bath is run off from time to time. The alumina alone undergoes decomposition, the oxygen combining with the carbon anode and escaping as carbonic anhydride. Anhydrous alumina is shovelled on to the surface of the bath as required, and serves to protect the fused mass below from loss of heat by radiation. Although attempts have been made to refine aluminium containing iron and silicon, they do not appear to have met with success, and it is therefore necessary to exclude these impurities from the materials used. The pure alumina used in the process is prepared from bauxite. A current of 7000 amperes is passed through each bath (the current density being probably about 2·5 amperes per sq. cm. of kathode), an E.M.F. of about 5 volts being required. The current efficiency is considerably less than the theoretical amount, owing to some secondary action, so that from 14 to 18 electrical horse-power hours are required to produce a pound of metal. The annual production of aluminium is rapidly increasing, and is at present considerably over 2000 tons. Notwithstanding the very large consumption of electrical energy in this manufacture, it is interesting to note that the cost of the pure alumina is the largest individual item in the total cost of production.

The problem of utilising aluminium presents as great difficulties as that of its economical production. Mr. A. E. Hunt, of the Pittsburg Reduction Company, has recently given an interesting account of the applications of aluminium, from which it appears that these difficulties are being overcome.

The energetic reducing action of aluminium is utilised in many ways, the most important being the production of steel castings; two to five ounces of aluminium per ton suffices to remove oxygen from the steel, and so to obviate to a great extent the formation of blow-holes in the castings. A little aluminium added from time to time to the baths of molten zinc used in galvanising, removes the oxide and keeps the baths fluid. The addition of a little aluminium in making brass castings increases their soundness and strength in a similar way.

Aluminium is also used instead of brass for a multitude of small cast and stamped objects which do not require to be soldered; there would still appear to be no trustworthy method of permanently soldering aluminium. Aluminium may possibly be used as a conductor of electricity, though at present the advantage in price lies with copper; the specific conductivity of aluminium is 63 to 64 per cent. of that of copper, whilst copper is 3·3 times as heavy.

The history of the electro-metallurgy of zinc is mainly a record of failures. Zinc is readily deposited from neutral or slightly acid aqueous solutions or from the fused chloride, but, from the former, is very prone to separate in a spongy form. Mylius and Fromm show that this is probably due to the formation of traces of oxide, and is prevented by the presence of reducing agents. Vigorous circulation of the solution is also advantageous. The presence of metals more electro-negative than zinc, which deposit on it and promote its oxidation, also produces the spongy deposit. The difficulty of insuring the absence of such metals from solutions obtained from zinc ores, as well as the low price of the metal, which precludes any elaborate purification, probably account for the slow progress of this industry. Progress is, however, being made. Dieffenbach's process is in successful operation at Duisberg in Germany. In this a solution of zinc chloride, obtained by leaching a zinciferous iron pyrites after submitting it to chlorinating roasting, is electrolysed; but further details are wanting.

The Ashcroft process obtains coherent zinc by employing a somewhat basic solution of zinc sulphate or chloride in the kathode compartments of the electrolytic cells, whilst the Siemens and Halske process employs somewhat acid zinc sulphate solution. Both these processes are at work on the large scale, but their ultimate success does not seem to be yet quite assured; so that a more lengthy description may be dispensed with.

At Tarnowitz an alloy of zinc and silver with a little lead and copper, obtained by desilverising lead with zinc containing about 0·5 per cent. of aluminium, was refined electrolytically, using a slightly basic concentrated solution of zinc and magnesium chlorides as electrolyte, and rotating zinc plates as kathode. The insoluble anode mud thus obtained contained about 75 per cent. of silver, and the zinc deposited was almost chemically pure.

Electro-galvanising is also now somewhat largely employed, the electrolyte being a solution of zinc sulphate. Here again close attention to the current density and composition of the solutions is required to secure a smooth and adherent deposit.

Nickel.—Whilst it is perfectly easy to deposit a very thin film of nickel by electrolysis, the metal peels off if a thicker deposit is attempted. According to Foerster, however, tough, homogeneous plates of nickel of any thickness may be deposited from aqueous solutions of the sulphate or chloride if they are heated to from 50° to 90° C. The nickel obtained is, however, not so pure as is the case with copper, cobalt and iron being found in the refined metal in about the same quantities present in the unrefined. Electrolytic nickel is now a commercial article, part of it being obtained from alloys of copper and nickel containing a considerable amount of sulphur, which are used as anodes, the copper being first deposited, whilst the nickel goes into solution, from which it is subsequently deposited.

The electrolytic removal of tin from tin-plate is said to be carried on to a considerable extent. The tinned scrap is suspended in iron baskets which form the anode, and the tin deposited in the spongy form on sheet-iron kathodes, the electrolyte being a solution containing 12 to 15 per cent. of sodium chloride, to which a little caustic soda is added from time to time to prevent the precipitation of stannous oxide. The solution is warmed to 40° or 50° C., and since tin dissolves under these circumstances independently of the electric current, it is necessary occasionally to evaporate the solution and work up the residue for sodium stannate. Sodium is now made exclusively by the electrolysis of fused caustic soda. In Mr. Castner's process the heat generated by the passage of the current is utilised to keep the bath in the fused state. Magnesium is also a product of electrolysis. The small quantity produced is made at Hemelingen, near Bremen, by the electrolysis of perfectly dry, fused carnalite (magnesium potassium chloride). The iron crucible in which the salt is melted serves as kathode, the central carbon anode being surrounded by a perforated porcelain or stoneware cylinder which retains the chlorine.

The application of electrolysis to the precipitation of gold from cyanide liquors, marks an advance of some importance in the metallurgy of gold. Gold is not completely precipitated in a reasonable time by zinc from solutions containing less than 0·1 or 0·2 per cent. of free potassium cyanide, whereas with the electrolytic process the concentration of the solution is a matter of indifference. It thus becomes possible, by the employment of very dilute cyanide solutions, to extract economically the small quantities of gold contained in slimes and tailings which would otherwise have been thrown away. A further advantage of the electrolytic precipitation is that the gold obtained contains some 89 per cent. of gold, instead of the 70 per cent. contained in the zinc bullion. The solutions to be electrolysed contain from 0·01 to 0·05 per cent. of potassium cyanide, according to the nature of the ore treated, together with from 1 to 4 dwts. of gold per ton of solution, in the form of potassium aurocyanide. They have, therefore, a very high resistance. Owing to the very small quantity of gold to be deposited, however, a very small current is sufficient (0·6 ampere per square metre), and the baths can be worked with the moderate E.M.F. of 4 volts. The quantity of electric energy required is thus small, and its cost is almost negligible compared with that of the rest of the process. The solution flows into the electrolytic tank at one end, and passes alternately over and under the electrodes until it flows out of the tank deprived of 80 to 90 per cent. of its gold. The kathodes consist of thin sheets of lead, and the anodes of iron enclosed in canvas bags to retain the precipitate of prussian blue which forms on them. They are placed about 1½ inches apart. The gold remaining in the liquors flowing from the electrolytic tanks is not lost, these liquors being made up to strength with fresh cyanide and used again. After remaining in the tanks some months the lead kathodes are sufficiently rich in gold to be removed and submitted to cupellation. Owing to the important advantages already mentioned, the employment of this process is rapidly extending; in 1896, two years after the first installation of the process, over 46,000 ounces of gold were obtained in the Transvaal by means of it, and at present it is much more extensively used.

Turning, now, to the application of electrolysis to the production of substances other than metals, there is an important group of industries engaged in the electrolysis of potassium and sodium chlorides, producing, according to the conditions employed, caustic alkalis and chlorine, hypochlorites or chlorates.

In the first case it is necessary to keep the primary products of the decomposition separate, and this is accomplished in two ways: (1) by the use of a porous diaphragm; (2) by means of mercury. The manufacture of a diaphragm which shall be sufficiently durable with a solution of caustic soda on one side of it, and of chlorine on the other, is by no means easy. The fact that diaphragms are being successfully used proves, however, that the difficulties are not insuperable. A more serious drawback is the impossibility of separating the caustic alkali from the chloride. As soon as the solution at the kathode contains hydroxyl ions, these begin to migrate, under the influence of the current, toward the anode, in time passing into the anode compartment and giving rise to the formation of hypochlorites and chlorates and to the evolution of oxygen, and so diminishing the efficiency of the cell. It is therefore necessary to draw off the solution from the kathode compartment of the cell while it still contains much undecomposed chloride, and to separate this from the caustic alkali as far as possible during the process of concentration.

The process of Hargreaves and Bird avoids this to a great extent in a very ingenious way. The kathode in this process consists of a sheet of copper gauze, upon which the diaphragm is built up of asbestos mixed with some cementing material. The diaphragm, with the copper gauze outside, forms the outer wall of the cell which contains the solution of salt and the carbon anode. The caustic soda is thus formed outside the cell, and is washed down and converted into carbonate by a mixture of steam and carbon dioxide. The diaphragm is made so impervious that, when in good condition, no liquid will run out of the cell, and only three molecules of salt to 100 molecules of sodium carbonate are obtained. The diaphragms last about thirty days, but, according to Kershaw, yield less favourable results toward the end of the time. Hulin's process is somewhat similar to that of Hargreaves and Bird, the diaphragm-kathode consisting of a sheet of porous carbon through which the caustic soda solution is forced as quickly as it is formed by hydrostatic pressure inside the cell.

When mercury is employed as the kathode, the diaphragm becomes unnecessary, the mercury taking up sodium in contact with the salt solution and giving it up to pure water in another vessel. A great many devices have been contrived for causing the mercury to alternately perform these functions. The simplest and most effective is undoubtedly the rocking cell of Mr. Castner. This consists of a shallow oblong tank divided into three compartments by means of partitions which do not quite reach the bottom. A thin layer of mercury lying on the bottom of the cell lutes the spaces below the partitions, thus dividing the cell into three separate compartments. The two end ones contain strong brine and carbon anodes, the central one pure water and an iron kathode which is connected electrically with the mercury. The cell is tilted slightly from side to side, so that the mercury flows from one end compartment to the other, always covering the floor of the central compartment, however. In this way the sodium taken up at the ends is conveyed to the water in the centre. The central compartment forms really a galvanic element, consisting of sodium amalgam and iron in a solution of caustic soda; the connection of the iron to the mercury short circuits this cell, and therefore hastens the dissolution of the sodium. The caustic soda obtained in this way is practically pure, and the current efficiency over 90 per cent. of the theoretical value; whilst the electromotive force required is 4 volts for each cell.

If instead of keeping the products of the electrolysis of a salt solution separate they are mixed together in the cold, a solution of hypochlorite is formed. A limit to the concentration attainable is, however, quickly reached, partly owing to the electrolysis of the hypochlorite, partly to its reduction by the hydrogen evolved. Hermite employs rotating zinc kathodes, between each pair of which a platinum gauze anode is fixed, the electrolyte, consisting of a solution of salt and magnesium chloride, flows through the apparatus, yielding a weak bleaching liquor suitable for bleaching paper pulp or for deodorising sewage, in which latter case sea water may be used. Kellner attains the same result by using a long tank in which a large number of carbon plates are fixed in such a way that the solution flowing in at one end of the tank must circulate between each pair of plates before passing out of it. Only the two end plates are attached to the terminals of the dynamo, so that each intermediate plate acts on one side as anode, on the other as kathode.

The electrolytic preparation of potassium chlorate was patented by Charles Watt as early as 1851, but the idea was not put into practice until 1889, when Gall and Montlaur started the first electrolytic potassium chlorate plant at Villers-sur-Hermes in Switzerland. They employ thin platinum-iridium anodes and iron kathodes, and maintain the solution at a temperature of 50° to 60° C. by the heat evolved by the passage of the current. The electrolytic cell is divided by a diaphragm of porous earthenware into a smaller kathode, and a larger anode compartment, in order to prevent as far as possible the reduction of the chlorate by the hydrogen evolved at the kathode. A current of 10 amperes per sq. dcm., and an E.M.F. of 5 volts are used, and the caustic potash formed at the kathode transferred to the anode compartment sufficiently fast to absorb all the chlorine evolved. The potassium chlorate crystallises out in the anode compartment, its solubility being diminished by the employment of a saturated solution of potassium chloride as electrolyte. The

diaphragm may be dispensed with, according to Oettel, if the solution is alkaline, because in that case potassium chlorate is not reduced, to any appreciable extent, by nascent hydrogen. High current density at the kathode, and low current density at the anode, promote the formation of chlorate, the best results being obtained when a quantity of oxygen is evolved, corresponding to some 30 or 40 per cent. of the current passed. The current efficiency is reported to be from 65 to 70 per cent., and there is no doubt that the electrolytic process will eventually displace the older chemical one, about one half of the world's consumption of chlorates being already supplied by it.

Of other electrolytic processes there is not very much to be said.

In Mr. A. B. Brown's process for the manufacture of whitelead a 10 per cent. solution of sodium nitrate is electrolysed in order to obtain caustic soda and nitric acid, which are subsequently used for the preparation of lead nitrate and its precipitation as lead hydroxide, the latter being finally converted into lead carbonate by means of a solution of sodium bicarbonate.

Applications of electrolysis to tanning and to the purification of sugar have been frequently proposed, but nothing very definite is known as to their success.

Among organic compounds iodoform has long been prepared by the electrolysis of an alkaline solution of potassium iodide containing alcohol. According to Elbs and Hertz good results are obtained by electrolysing a solution containing 5 to 6 grams of sodium carbonate, 10 grams of potassium iodide and 20 cc. of alcohol in 100 cc. of water at a temperature of 60° C. with a current density not exceeding 1 ampere per square decimetre. Under these circumstances the current efficiency is over 97 per cent. and the iodoform produced perfectly pure.

It has been proposed to apply ozone to a great variety of purposes, but here again a lack of trustworthy information about the results is found. According to Mr. Swan, however, it is used in making vanilin and heliotropin. When used as a bleaching agent it is necessary to use it in conjunction with other substances, such as hypochlorites or hydrogen peroxide. Mr. Andreoli has devised an ozone producer in which the electrodes are furnished with numerous points and separated by a glass plate. In order to prevent the heating of the gas it is caused to pass rapidly throught the apparatus, and the electrodes are made hollow and cooled by internal circulation of water. The silent discharge is obtained by means of an alternating current dynamo and high tension transformer yielding a rapidly alternating current at a pressure of 10,000 volts or more. By this means 30, or under favourable conditions 40 grams of ozone are obtained for a horse-power hour.

Electro-thermal Processes.—The electric current possesses two considerable advantages as a heating agent; in the first place temperatures otherwise unattainable may be reached by its aid, and secondly the heat may be applied directly and economically to the substances which are to be caused to react. The three most important products of the electric furnace are carborundum, phosphorus, and calcium carbide.

Carborundum, a compound of carbon and silicon in equal atomic proportions, was prepared by Acheson in 1891, in the course of experiments on the artificial production of the diamond. It is remarkable for its extreme hardness, which is only inferior to that of the diamond. It is prepared by heating a mixture of powdered coke and sand, to which a little sawdust and salt are added in order to make the mass more porous, in a furnace 16 feet long, 5 feet wide and 5 feet deep, which is built up of loose firebricks. Through the end walls of the furnace bundles of 60 carbon rods, each 3 inches in diameter pass, which are connected inside the furnace by a cylindrical core of small pieces of coke. This core is surrounded on all sides by the mixture of sand and coke. The passage of the current through the core gives rise to a cascade of small arcs between the pieces of coke, which soon raises the whole core to a very high temperature which is communicated to the surrounding charge. A current of 6000 amperes at 125 volts pressure is passed for 36 hours, after which the furnace is allowed to cool and the hollow cylinder of crystalline carborundum surrounding the core removed. About 5·3 electrical horse-power hours are expended in producing a pound of the crystalline product, a considerable quantity of valueless, amorphous carbide of silicon being also formed at a greater distance from the core, where the temperature is lower. The carborundum is obtained in the form of steel grey to brownish green crystals, the coloration being due to iron; it is a valuable abrasive, cutting the hardest steel without destroying its temper; and is being largely used in place of emery. The production has increased from 15,000 pounds in 1893, when it was first made on a manufacturing scale, to about one and a half million pounds in 1897.

The manufacture of phosphorus in the electric furnace has been carried on for some years by means of the process of Readmann and Parker and Robinson. Wöhler found, as long ago as 1830, that phosphorus may be obtained from calcium phosphate by heating it to a high temperature with sand and carbon, calcium silicate and carbon monoxide being produced. The employment of the electric furnace has made it possible to use this process for the manufacture of phosphorus. Naturally occurring phosphates are used and siliceous material added, which will furnish a readily fusible slag. The finely-powdered mixture of these substances with carbon is fed in through a hopper at the top of a brick-lined trough, 18 inches square and 36 inches deep, through opposite sides of which the carbon electrodes are introduced. The fused slag collects at the bottom of the furnace, whence it is run off from time to time in the same way as in a blast furnace, whilst the mixture of phosphorus vapour and carbonic oxide pass to the condensing apparatus through an opening placed near the top of the furnace. More than 80 per cent. of the phosphorus contained in the materials used is obtained, the loss being largely due to the presence of iron which combines with phosphorus to form a phosphide which remains in the slag. The heat is concentrated mainly between the electrodes, so that the walls of the furnace do not suffer.

Calcium carbide was prepared by electrically heating together carbon and lime, in 1892 by Moissan in France, and by Willson in America; its manufacture is now carried out on a very considerable scale, both in America and in Europe. The production is said to be about 20,000 tons yearly. The furnaces employed vary considerably in details of construction and in magnitude. Those employed at Niagara consist of a square brickwork shaft in which a bundle of carbon rods, which forms one electrode, is suspended. The bottom of the shaft is closed by an iron rectangular box, running on rails, the bottom of which has a thick lining of carbon, which serves as the other electrode. The finely-powdered mixture of coke and lime is fed into the space round the upper electrode through channels in the brickwork sides of the shaft. The arc having been established between the electrodes, the mixture of coke and lime is shaken down into it, and converted into calcium carbide, which remains in a semi-fluid condition upon the lower carbon plate. The calcium carbide, being a fairly good conductor of electricity, now serves as the lower electrode, fresh material being constantly added to its upper surface until the iron box is full, when it is run out and a fresh one substituted for it. The current employed is 1700 to 2000 amperes, and the electromotive force 100 volts, a pound of the carbide being obtained for an expenditure of 2·25 electrical horse-power hours. When sufficient carbon is employed in the mixture, the electrodes are very little acted upon; the excess of carbon which is required depends very much on the kind of apparatus employed. A pound of well-made carbide yields 5 cubic feet of acetylene gas, the employment of which for lighting appears to be making some progress.

In concluding this brief sketch of the applications of electrochemistry, it is perhaps worth pointing out that, important and interesting as are the applications which have been made, those which yet remain are still more so. For example, it is possible, by compressing sulphur dioxide and air into separate carbon tubes dipping in dilute sulphuric acid, to cause the two gases to combine to form sulphuric acid, and at the same time furnish an electric current. The alluring prospect of obtaining electric energy as a bye-product in a chemical works, should be a sufficient incentive to efforts to overcome the numerous difficulties in the way.

THOS. EWAN.

THE STRANGLING OF AN ELEPHANT.

ONE of the elephants in Barnum and Bailey's Show, which has been visiting Liverpool during the past two weeks, having recently shown signs of insubordination, Mr. Bailey determined, in order to perfectly safeguard his visitors, to sacrifice the animal. He has had during his life occasion to destroy many elephants, which, as a rule, he has handed over to experienced veterinary and other surgeons, who have tried various methods, such as poisoning, shooting and bleeding. All have proved, however, unsatisfactory, because uncertain, tedious, and not seldom dangerous to those engaged in conduct-

ing the operations. On this occasion it was determined, after consultation with several experts and with the Secretary of the Royal Society for the Prevention of Cruelty to Animals, to kill the elephant by strangulation, which had once before been adopted with success by Mr. Bailey. Accordingly it was arranged that on a recent Sunday morning—the day most suitable to the Show people and that freest from intrusion by the public—Don, as the doomed elephant, who was supposed to be about twenty-two years of age and nearly 4½ tons in weight, was named, should be strangled.

At the appointed hour those specially invited—among whom were several veterinary surgeons, Dr. Forbes, Director of the Liverpool Museums (to whom the body was generously to be handed over as a gift from Mr. Bailey to the Museum), Dr. Roberts, and Mr. Burnham, of the Society for Prevention of Cruelty to Animals—found the elephant standing quietly in one of the large tents in line with some twenty to thirty others. A new Manilla rope was loosely wound three times around its neck, and its legs, fully stridden, were securely chained each to a post firmly driven into the ground alongside each limb. The animal was intentionally not isolated from its fellows, as it was feared that if separated by itself it would become restive and ill-tempered. The rope surrounding the beast's neck had one end secured to three strong pillars in the ground, some distance away and slightly in advance of the fore-feet; and the other, which terminated in a loop, was hooked to a double series of pulleys, to the tackle of which ninety men were attached. When all was ready, the slack was gently, quietly, and without any apparent annoyance to the elephant, which kept on eating hay, taken in till the coils round its neck were just taut. The word was then given, "Walk away with the rope." Amid perfect silence the well-disciplined company walked away with it without the least effort. So noiselessly and easily did everything work that, unless with foreknowledge of what was going to take place, one might have been present without realising what the march of these men meant. The elephant gave no sign of discomfort, either by trunk or tail; its fellows standing close by looked on in pachydermatous unconcern, and at the end of exactly thirty seconds it slowly collapsed, and lay down as if of its own accord. There was absolutely no struggle, and no motion, violent or otherwise, in any part of the body, nor the slightest indication of pain. In a few seconds more there was no response to the touch of its eyelashes or other parts of the eye, and this condition remained for a few minutes; but through, perhaps, the leakage into the chest of a small quantity of air, some slight sensitiveness returned to the eye, seen on touching its inner angle, though not the cornea. On slightly tightening up the rope, the chest gave one or two short throbs, and after six and a half minutes all movement ceased, and sensation was entirely lost; while at the end of thirteen minutes from the order "to walk away," the eye had become rigid and dim.

That no more humane, painless and rapid method of taking the life of a large mammal could be devised, was the opinion of all the experts who witnessed the execution of this elephant.

The skin and skeleton have been preserved for exhibition in the Municipal Museums, and all the important viscera have been placed in Formal, for future study by the Director and his staff. Prof. Paterson and Dr. Dunn, of University College, who very kindly aided in the dissection, have made a full study of certain parts of the nervous system, which they had not completed in the dissection made by them (on which they have recently contributed a valuable paper to the *Journal of Anatomy and Physiology*) of the "rogue" elephant poisoned last year in Liverpool. These points, and others which may turn out to be of interest on the fuller dissection of the present specimen, will be published in the *Bulletin* of the Liverpool Museums.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—On Tuesday evening, May 24, the Oxford University Junior Scientific Club held a very successful conversazione at the University Museum, which was tastefully decorated and lighted for the occasion. Over 1000 persons attended, and were received by the President, Mr. W. E. Moss (Trinity), and the other officers of the club. For the entertainment of the guests numerous exhibits and demonstrations of the most varied description were on view in the central court and the adjacent departments; and in the large lecture theatre two lectures were given: the first, by Prof. H. B. Dixon, F.R.S., of Owens College, Manchester, on "Climbing in the Rocky Mountains"; and the second, by Dr. Gustav Mann (New Coll.), on "Microphotography," both being well illustrated by lantern slides. A short lecture was also given in the geological lecture theatre by Mr. G. J. Burch, on "Artificial Colour-Blindness," in which evidence was brought forward to show that, instead of three, there are really four colour-sensations—red, green, *blue*, and violet. The reason so many experimenters have only detected three, is that a large number of people are colour-blind to either blue or violet. The lecturer's experiments consisted in fatiguing the optic nerve by exposure to special parts of the spectrum, and it was thus shown that the pure blue of the spectrum between violet and green could be eliminated. The Radcliffe Library was open during the evening, by kind permission of the librarian (Sir Henry W. Acland, Bart., K.C.B., F.R.S.), as was also the Pitt-Rivers' Collection, by permission of Mr. H. Balfour, the curator. The band of the Royal Artillery, with Sergt.-Major W. Sugg as conductor, gave an excellent selection of music.

IN view of the importance of ascertaining, with such accuracy as the conditions allow, the number of pupils receiving instruction in public and private secondary schools in England, the Lords of the Committee of Council on Education are repeating the inquiry first made in May 1897. Forms of inquiry have been sent to all those schools which are understood to be giving secondary education, and if one has not been received by the principal teacher an application to the Secretary of the Education Department will ensure the papers being sent.

VOTING by means of ballot papers through the post, Convocation of the University of London have placed Mr. J. Fletcher Moulton, who opposes the scheme for a teaching University, first on the list of those from whom Her Majesty will select a member of the Senate in succession to the late Sir Richard Quain. The two other candidates were Dr. J. B. Benson and Mr. P. Daphne. Mr. Moulton headed the poll by more than two hundred votes. It is not anticipated that the result of this election will influence the Government's intention to introduce the London University Bill at an early date.

THE London County Council has decided to lay out plots of ground in Battersea, Ravenscourt, and Victoria Parks in such manner as will afford assistance to scholars at elementary and secondary schools in the study of practical botany. Hardy typical plants belonging to twenty natural orders will be arranged in beds near the paths, one bed being devoted to each order. Each specimen will be labelled with its common name and its Latin or systematic name. Labels giving the names and natural orders will also be attached to the more important trees, shrubs and plants throughout the parks mentioned. Teachers holding printed orders issued by the Technical Education Board will be able to obtain from the superintendent in each park such specimens as may be required for botanical study. It is hoped that later on the arrangements may be extended to the cultivation of important types of the lower orders of plants, such as fungi, mosses, ferns, liverworts, &c., and facilities afforded for the study of aquatic plants.

A REPORT on the International Congress on Commercial Education, recently held at Antwerp, is given in the *London Technical Education Gazette*. The following items from the report are of interest:—The view of the majority of delegates present at the Congress was that *specialised* commercial education should not be commenced in primary and secondary schools, but that there was ample room for the development of higher commercial teaching. It is a significant fact that the city of Antwerp spends 2½ millions of francs on education out of a total revenue of 4 millions of francs. In connection with the discussion of the question as to what extent special commercial instruction should be given in secondary schools Dr. Stegemann, official German delegate, gave a long account of the German schools, more particularly of the "Realschulen" and of the "Fortbildungsschulen" (continuation schools). He said that the latter were principally supported by leading merchants and members of mercantile corporations, because they fully recognised the importance of giving to their clerks a theoretical education as the complement to their office training. Dr. Stegemann said that commercial instruction could be given

in the secondary schools, without any specialisation whatever. "We in Germany do not care to know anything about a river unless it will float a ship, and new countries interest us only when they afford an outlet for our industry." Speaking afterwards upon the past and present of commercial education in Germany, Dr. Stegemann pointed out the solidarity which existed between the professors of their schools and the commercial men of the country, a union which led to the happiest results, inasmuch as the latter had given to the former the benefit of their practical business experience. In conclusion, he said that he ventured to counsel English educationists not to lose sight of the fact that, even in Great Britain, they must give to their young men a more extended and practical course of study if they wished to maintain the commercial prestige of their country. As to the aim of the continental higher commercial institutes, M. Heinzmann Savigno (Antwerp) said the object pursued at the Antwerp Institute, and at the other establishments modelled upon it, was not to furnish "clerks" in the ordinary acceptation of the word, but "merchants," who would be able to transact their business on a scientific basis, and give to their commercial transactions an impetus which would materially extend their country's home and foreign trade. They also aimed at the creation of men who would be properly prepared to be themselves professors of the higher commercial sciences, or to go forth into the world and effectively undertake the duties of the consular service. The speaker added that, in order to keep pace with the growing extension of colonial enterprise, he would strongly advocate the formation of a special class of men competent by their knowledge to take the lead in colonial development.

SCIENTIFIC SERIALS.

American Journal of Science, May.—On the properties of seasoned magnets of self-hardening steel, by B. O. Peirce. In searching for a material of which to make a set of standard measuring magnets which should be as permanent as possible and have small temperature and induction coefficients, the author tested a number of magnets made of some of the brands of "self-hardening" tool steel now in common use for lathe tools. He found that the temperature coefficient could be reduced almost indefinitely by cutting the rods long and thin.—Some lava flows of California, by F. L. Ransome. This paper deals with a strip of the middle, western slope of the Sierra Nevada. The volcanic eruptions began during the Miocene period and continued to the end of the Pliocene. The deposition of auriferous gravels both preceded and accompanied the deposition of volcanic material. The author distinguishes three separate flows of lava, which were eventually brought to an end by fresh andesitic eruptions. During Pleistocene time the present streams have dissected the Neocene lavas and tuffs, and have deeply cut into the Jurassic and older rocks.—Some new Jurassic vertebrates from Wyoming, by W. C. Knight. The University of Wyoming has in its collection of Jurassic vertebrates partial remains of four swimming saurians that in a general way resemble Plesiosaurs. The discovery of these remains is of considerable value to American Mesozoic geologists for correlating the American and European Jurassic. The largest of the four species surpasses in size the European Pliosaur, and it is described under a new genus, *Megalneusaurus*. The description given is founded upon a cervical, dorsal, and caudal vertebra; one fore-limb nearly complete; ribs, and the greater portion of the pectoral girdle. The genus represents the largest known animals of the order Sauropterygia.—On the estimation of manganese separated as the carbonate, by Martha Austin. The carbonate precipitated by means of alkaline carbonates is very uncertain. An improvement in the quantitative analysis may be effected by converting the carbonate first into oxide and then into sulphate by heating with a few drops of concentrated sulphuric acid.

Symons's Monthly Meteorological Magazine, May.—The climate of Algeria, by Dr. A. Thevenet, director of the Algerian Meteorological Service. The first subject dealt with is temperature. The absolute maximum in the shade is 122° at Orléansville (lat. 36° 40′ N., long. 1° 19′ E.), and the absolute minimum is given as 6°·8, at El-Aricha (lat. 34° 16′ N., long. 1° 23′ W., altitude 4364 feet). Sharp frost is not infrequent on the Sahara, but on the Mediterranean coast frost is rare. The air is not so dry as might have been expected; monthly means below 40 per cent. are very rare, except on the high plateaux and on the Sahara. The mean annual rainfall at Algiers, as recorded at four stations between 1838 and 1895, is 30·16 inches, but there is considerable divergence between the different records.—Results of meteorological observations at Camden Square (London) for April for forty years, 1858–97. The mean of all the highest maximum temperatures was 70°·7, and the mean of all the lowest minima was 29°·8. The average monthly rainfall was 1·66 inches, while in April of this year it was only 1·01 inches.—The gloomy summers of 1860 and 1879, and the nineteen years' cycle, by H. A. Boys. The author points out that there has been so obvious a parallel between most of the last few years and those years that preceded them by 19 and 38 years respectively, that ground has been given for watching whether the summer of 1898 will not prove gloomy and rainy like those of 1860 and 1879, at least in the midland counties.

Wiedemann's Annalen der Physik und Chemie, No. 4.—Some modifications in the quadrant electrometer, by J. Elster and H. Geitel. The drying apparatus is a wide side tube off the chamber containing the quadrants. It contains a wire attached to the movable end cover, and the point of the wire carries a piece of sodium, wiped or scraped to remove adhering petroleum or oxide. Below the sodium is a glass bulb, which catches the dripping moisture. The sodium is surrounded by a wire net to prevent its dropping bodily into the liquid.—Duration of electric oscillations of large periods, by J. Bergmann. Describes an improved apparatus for measuring oscillations with periods over one-millionth of a second.—Fluorescence and actino-electricity, by G. C. Schmidt. E. Wiedemann and the author have propounded the theory that the molecules, split up into ions by the action of light, give rise to fluorescence on recombination. This would lead to the conclusion that fluorescent bodies could not easily lose negative ions on exposure to light, *i.e.* would not be photo-electrically or "actino-electrically" sensitive. This conclusion is, however, not borne out by experiment, as no connection between the two phenomena can be established. It is found, on the other hand, that bodies which exhibit the strongest thermo-luminescence show also the strongest photo-electric action.—A new method of measuring dip and horizontal intensity, by G. Meyer. The dip may be measured without a magnet and without a galvanometer by means of a continually revolving inductor coil and a telephone. The axis of the coil is adjusted to the telephone minimum. The measurements are correct to within 3′ of arc. To measure the horizontal intensity, the earth's field is compensated by the field due to a current of known strength. Complete compensation is indicated by silence in the telephone.—An instrument for measuring astigmatism, by R. Straubel. This consists of two cylindrical lenses which rotate with respect to each other about a common axis. Artificial astigmatism of any given amount may thus be produced.

FROM the articles in the *Journal of Botany* for March–May, we may select the following as of the most general interest:—The fifty years' limit in nomenclature, by the editor; in which he shows how impossible it would be to work such a rule in practice. Notes on Mycetozoa; and Mycetozoa of Antigua and Dominica, by Mr. A. Lister. Experiments in cross-fertilisation of *Salices*, by Mr. G. F. Linton. Some species of willow cross with great readiness, others with reluctance, and others obstinately resist all attempts at hybridisation. Wayfaring notes in Rhodesia, by Mr. R. F. Rand. The work of cross-fertilisation of the native flowers of Rhodesia appears to be effected largely by butterflies; but by far the most active agents are beetles.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 5—"On certain Structures formed in the drying of a Fluid with Particles in Suspension." By Catherine A. Raisin, B.Sc. Communicated by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S.

Experiments have been made with various muddy fluids, which were allowed to dry under certain conditions, in order to study the forms assumed by the dried material. It seemed possible that these forms might throw some light on the origin of certain minor structures in rocks. Various pigments or powdered rocks (mostly very fine grained) were mixed with water and placed on microscope slides or larger pieces of glass, generally beneath a cover-glass.

In materials not of the very finest grain (*e.g.* prussian blue), the forms shown by the dried powder consist usually of two sets of elements, coarser and finer. The former tend to develop as branching stems, which are either bent and winding, forming a kind of maze, or somewhat rectilinear with terminal knobs. The finer material forms a feathery or fan-shaped pattern, generally at the margin of the deposit, and in the intervals between the coarser stems. It consists of successive curving lines, or of radial streaks and furrows. The different structures are combined in various patterns, of which one illustration is reproduced (Fig. 1). In addition, vesicular structures, cracks, and joints are developed in the dried mud, some of the cracks bearing even a certain resemblance to the appearance in frozen gelatin described by Prof. Sollas (*Trans. Roy. Ir. Acad.*, 1890). The mode of formation was studied by watching the films in the process of drying, and by comparing different examples. As the edge of the film gradually retreats, coarser stems begin to form, while fine material, remaining for a time in moist condition, afterwards dries as the fine pattern.

These various forms seem to illustrate, more or less closely, structures which occur in nature. Thus, dendritic deposits along joint-planes, or on other surfaces in rocks, although undoubtedly they often are the effects of crystallisation, may be sometimes formed by mechanical drying, or both conditions may co-operate. It is possible that some of the "pseudorganic" structures described in rocks, might really be the casts or replacements of dried streaks. Similar principles to those shown in these films may govern the formation of structures in

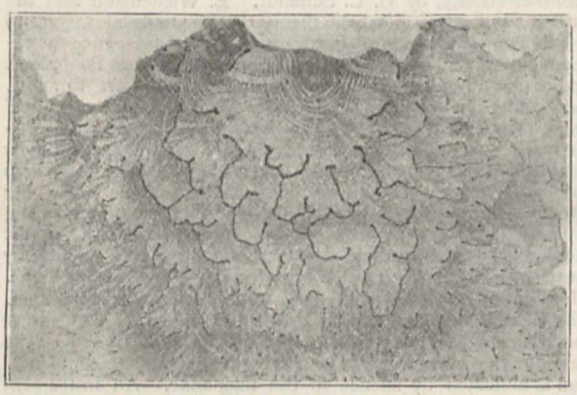


FIG. 1.—This shows near one edge a fine pattern with concentric lines and radial furrows; then coarser bent stems, which become smaller and reduced towards the further margin, while the fine material forms rather feathery tufts. Prussian blue. (Natural size.)

the mass of a rock, as, for example, the development of Landscape Marble (as explained by Mr. B. Thompson), or the growth of some agates and chalcedonic deposits. Even the solidification of certain igneous rocks, or the processes of secondary silicification, may be somewhat analogous. Further, the similarity shown in cracks and vesicles to those in some pyromerides seems to give support to the hypothesis that these nodules at an early stage were often in a semi-solidified condition with an external crust.

In conclusion, the forms resulting from the processes of crystallisation, which have been described in numerous papers by different authors, may be shortly compared; and some additional experiments have been made, especially as to the effects produced by the admixture of material in suspension (or of a colloid) with the solution of a crystallising salt. Spherulitic and dendritic forms, as described by Lehmann and other observers, may be developed, or even an imitation of micropegmatitic structure. Certain interesting forms of ice crystals (shortly described in NATURE, 1892, by Prof. Meldola, Prof. Bonney, and others) are shown, in a note by Prof. Bonney, to have been developed under somewhat similar conditions.

"The Relations between the Hybrid and Parent Forms of Echinoid Larvæ." By H. M. Vernon, M.A., M.B. Communicated by Prof. Ray Lankester, F.R.S.

The object of this research was to determine systematically, during a period of several months' duration, the exact relationships of structure and size existing between certain hybrid and parent Echinoid larval forms. The method of procedure was similar to that described in a former paper (*Phil. Trans.* B., 1895, p. 577).

Upon the cross *Sphærechinus* ♀ -*Strongylocentrotus* ♂, twenty-two experiments were made. As a rule only 10 per cent. of the ova were fertilised, and only 1 per cent. of them reached the eight days pluteus stage. The hybrids were most easily obtained in the summer months, few or none of the ova being cross-fertilised in the winter. The hybrids obtained in May, June, and July were of an almost pure *Sphærechinus* type, only a third or less of them being of an intermediate or *Strongylocentrotus* type. In November, on the other hand, only about a sixth were of the maternal, and five-sixths of a semi-paternal type. Finally, in December and January all the hybrid larvæ were of this paternal type.

On the reciprocal cross of *Strongylocentrotus* ♀ and *Sphærechinus* ♂ eighteen experiments were made. During April, May, and June a fair number of the ova were cross-fertilised, but no plutei were obtained. In July and August some 47 per cent. of the ova were fertilised, and 29 per cent. of them survived to the eight days' pluteus stage. In November and December, on the other hand, not only were no plutei obtained, but as a rule not a single ovum was cross-fertilised. The hybrid larvæ themselves were of the pure *Strongylocentrotus* type.

These extraordinary variations in the capacity for cross-fertilisation seem to be due to the variations in maturity which the sexual products undergo with change of season. Thus in July and August most of the *Strongylocentrotus* individuals contain but very small quantities of ripe sexual products, or none at all; and the larvæ obtained may be as much as 30 per cent. smaller than those obtained in the winter and spring. At intermediate times of the year the larvæ are of intermediate size. It appears, therefore, that the *Strongylocentrotus* ♀ -*Sphærechinus* ♂ hybrid is only formed at the time when the *Strongylocentrotus* ova have reached their minimum of maturity; whilst in the case of the reciprocal hybrid, it follows that as the maturity of the *Strongylocentrotus* sperm increases, it is able to transform first a portion and then the whole of the hybrid larvæ from the *Sphærechinus* to its own type. In other words, the characteristics of the hybrid offspring depend directly on the relative degrees of maturity of the sexual products.

As a result of the ten experiments made on the cross *Echinus* ♀ -*Strongylocentrotus* ♂, it was found that the hybrid larvæ were on an average about 8 per cent. *larger* than the pure parental larval forms, and, moreover, that even more of the cross-fertilised ova developed to plutei than of the directly fertilised ones. In the reciprocal cross, only about 1 per cent. of the ova reached the pluteus stage, and these plutei were about 13 per cent. smaller than the pure maternal larvæ.

Various crosses, in several instances reciprocal ones, were also effected between *Strongylocentrotus*, *Sphærechinus*, *Echinus microtuberculatus*, *Echinus acutus*, *Arbacia*, *Echinocardium cordatum*, *Echinocardium mediterraneum* and *Dorocidaris*.

On performing cross-fertilisations with the colour varieties of *Sphærechinus*, there was found to be a distinct diminution of fertility. Series of experiments were made in June, July, November and December, the differential fertility seeming to gradually diminish with the progress of the season. Nevertheless, it was always most distinctly present. There was little or no infertility between the less definitely marked colour varieties of *Strongylocentrotus*.

April 28.—"A Compensated Interference Dilatometer." By A. E. Tutton, Assoc. R.C.S. Communicated by Captain Abney, C.B., F.R.S.

The author describes a form of Fizeau interference dilatometer which he considers combines the best features of the apparatus described by Benoit, and belonging to the Bureau International des Poids et Mesures, in Paris, and that described by Pulfrich, constructed according to the modifications introduced into the method by Abbe. Moreover, besides other improvements, a new principle, that of compensation for the expansion of the screws of the Fizeau tripod which supports the object, is introduced, which enhances the sensitiveness of the method so highly as to render it applicable to the determination of the expansion of crystals in general, including those of chemical preparations. Hitherto the application of the Fizeau method has been confined to such crystals as could be obtained large enough to furnish a homogeneous block at least a centimetre thick. A block only 5 mm. thick is ample for use with the author's compensated dilatometer. The principle of the compensation

depends upon the fact that aluminium expands 2·6 times as much as platinum-iridium for the same increment of temperature. The author therefore employs, like Fizeau and Benoit, a tripod of platinum-iridium, and places upon its transverse table, through which pass the three screws, a disc of aluminium whose thickness is 1/2·6ths of the length of the screws. The space between the lower surface of the glass plate which is laid upon the upper ends of the screws to assist in producing the interference, and the upper surface of the aluminium, then remains constant for all temperatures under observation, and if a crystal is laid upon the aluminium compensator the whole amount of its expansion by rise of temperature is available for measurement by the interference method. Hence the method is no longer a merely relative one, affording the difference of expansion between the tripod and the substance investigated, but affords directly absolute measurements of the expansion.

The results of numerous determinations of the expansion of the platinum-iridium of the tripod are given, carried out with the surface of the tripod table and the cover-wedge separated at the long interval of 12 mm., by the aid of green mercury light. The mean value is very similar to that of Benoit, and is

$$\alpha = 10^{-9}(8600 + 4{\cdot}56t).$$

The result of several determinations in red hydrogen light of the expansion of the pure aluminium used for the series of compensators, carried out by the Fizeau relative method with a block 12 mm. thick, is

$$\alpha = 10^{-8}(2204 + 2{\cdot}12t).$$

Similar determinations for the black glass of the crystal-covering plates afford the value :

$$\alpha = 10^{-9}(7257 + 10{\cdot}4t).$$

In a subsequent memoir the author intends to present the results of determinations of the expansion of the sulphates and selenates of potassium, rubidium, and cæsium.

Physical Society, May 27.—Mr. Shelford Bidwell, President, in the chair.—A paper by Messrs. Edwin Edser and C. P. Butler, on a simple method of reducing prismatic spectra, was read by Mr. Edser. The production of interference-bands in a continuous spectrum is capable of furnishing a reference-spectrum, which can be employed to determine the wave-lengths corresponding to the bright lines in a spectrum of a metal or of a gas. The authors discuss various methods by which such bands can be formed. In their final experiments, an air-film between two plane parallel glass plates is inserted in front of the slit of the spectrometer, in the path of the incident light. Owing to the interference of the direct ray with that twice internally reflected, bright bands separated by dark intervals are observed in the spectrum ; these bright bands correspond to a series of different waves, whose lengths are easily determined for the whole series, when two of them are known. The bands are much improved by partial silvering of the two internal surfaces of the glass. It has been found that ordinary plate-glass, if well chosen, is good enough for all these experiments. In order to adjust for parallelism, a spot of light, or the filament of a glow-lamp, is viewed through the silvered surfaces. A long train of images is generally visible ; these must be brought into coincidence. If now a sodium flame is looked at through the film, interference bands are seen. These bands must be adjusted by pressure, to be as broad as possible. An arc-lamp is used for illuminating the collimator slit. The authors exhibited the apparatus, and showed photographs of spectra-scales with the appropriate wave-lengths, calibrated upon them by this method. The results there obtained were read from the spectrometer to 0·4 of a tenth-metre, with an ordinary pocket-lens. A simple graphic method enables wave-lengths, corresponding to a great number of spectral lines, easily to be determined by inspection. The phase-changes introduced by the silver do not affect the final result. Prof. Threlfall congratulated the authors on their discovery of a method that would greatly reduce the labour of calibrating spectra, and at the same time give such accurate results. Prof. Boys said the simplicity of the apparatus added greatly to the value of the method. It would seem to him better if the slit were somehow contrived within the film-space. All want of definition due to rays falling at different angles upon the collimator object-glass would thus be avoided, and only a small part of the glass plates, *i.e.* the slit, would require to be strictly parallel planes. The limit of accuracy in the authors' method depended upon the collimator, not upon the optical perfection of the silvering of the plates. Mr. Butler pointed out that previous methods had always required experienced spectroscopists for mapping-out results. In the new method that work could easily be done by an assistant. Mr. Edser said that by putting the two plates immediately in front of the slit only a very small part of the glass is concerned in the action, light coming through at an angle would not reach the lens in the collimator.—Prof. Boys, Vice-President, then took the chair, and Mr. Campbell Swinton read a paper on some further experiments on the circulation of the residual gaseous matter in Crookes' tubes. In the discussion that followed the former paper on this subject, at the Physical Society on March 25, 1898, Mr. Appleyard had suggested that, in tracing the cause of the rotation of the exploring mill, it would lead to simpler results if the vanes were made of some light conducting substance, for it was probable that mica introduced complications by retaining the charges. Prof. Boys then pointed out that the mica might be gilded. Such a tube has now been made by Mr. Wolff. With the gilded mica vanes so placed as to be outside the kathode stream, the mill behaves in a manner similar to the non-conducting insulated mill. It shows a greater tendency to assume a position of stability, due to electrostatic induction ; this renders it somewhat troublesome in starting, but, when once under way, the mill rotates always when excited. Occasionally, when starting, a few reverse revolutions are observed ; these are probably due to electrostatic influence and momentum, and also possibly to eddy currents in the residual gaseous matter. But it is found, in all cases, that rotation in the direction that indicates a stream of residual gaseous matter from anode to kathode, follows the reversal immediately after one or two oscillations. An electrometer connected to the mill through the pivot and needle-point, shows the vanes to be always electrified positively. The results are confirmed by a second tube with oblique vanes. The author concludes that at very high exhaustions there exists a molecular or atomic stream from anode to kathode, which carries a positive charge, and travels at high velocity outside the opposite kathode stream. Mr. J. Quick asked what was the minimum degree of exhaustion required to produce these results. Prof. Boys said that the experiment gave some amount of probability to the truth of Mr. Campbell Swinton's hypothesis, but it did not altogether prove the mechanical theory of rotation to be correct. He was glad that the chance suggestion at the last discussion had led to such interesting experiments being continued. Prof. Threlfall mentioned that Boettger had devised a method for gilding mica, by a chemical process, that was much to be preferred to ordinary gilding. Mr. Campbell Swinton said it was necessary to exhaust the tubes as completely as possible to a point where it was only just possible for any discharge at all to pass through them. If the rotation was due to electrification, there must still be some mechanical process whereby the charges get to the vanes—a stream of residual gas satisfied that condition.—The Vice-President proposed votes of thanks, and the meeting adjourned until June 10.

PARIS.

Academy of Sciences, May 23.—M. Wolf in the chair.—Notice on the late M. Souillart, Correspondant in the Section of Astronomy, by M. O. Callandreau.—Some remarks on the periods of double integrals, and on cycles of two dimensions in algebraic surfaces, by M. Émile Picard.—New researches on the reaction between pyrogallol and oxygen in presence of alkalies, by M. Berthelot. The reaction depends upon the nature of the alkali employed. The amounts of oxygen absorbed, and carbon monoxide evolved, were measured and the oxidation products studied.—Chronophotography applied to the study of muscular action in locomotion, by M. Marey. The paper is accompanied by four plates, illustrating the methods used. After a set of photographs of the living animal has been obtained, its skeleton is prepared, and these photographed upon the same scale. From these the curves of change of length of each muscle can be deduced.—The origin of the vertebrates, by M. Edmond Perrier.—On minimum surfaces, by M. C. Guichard.—On systems of differential equations which satisfy quadruply periodic functions of the second species, by M. Martin Krause.—On the determination of the terminal curves of spirals, by MM. C. E. Guillaume and J. Pettavel. A mechanical method for determining Phillips' curve for spiral balance springs.—On a new method of determining the mechanical equivalent of heat, by MM. J. B. Baille and C. Féry. A cylinder of copper is fixed in a rotating magnetic field, and the heating effect measured. The moment of the couple required to keep the sphere at rest and the velocity of the field can be exactly

measured. The correction for cooling must be measured with great exactness. In the preliminary results quoted the values of J lie between 422 and 426.—On some experiments in submarine acoustic telegraphy with the aid of a microphone, by M. E. Hardy.—On the osmosis of liquids through a membrane of vulcanised rubber, by M. G. Flusin. Since the measurement of the limiting osmotic pressure could not be carried out with this membrane, the velocity of the osmotic current was determined from the liquid into ethyl alcohol. The amounts of liquid absorbed by the rubber were also determined, but these figures are not proportional to the velocities of osmosis.—Improvement of over-exposed negatives, by M. Mercier. The plate is immersed for two minutes in a solution of tartar emetic, dried and developed as usual with hydroquinone.—On an apparatus for aërating boiled or distilled water, by M. Maillet.—Recapitulation of the atomic weights calculated by the method of limited densities, by M. Daniel Berthelot. By the methods given in preceding notes the atomic weights of carbon, sulphur, nitrogen, and chlorine are calculated. The agreement between the numbers so obtained, and those obtained by chemical methods is so close that the original assumption may be regarded as proved, Avogadro's law being strictly true only at extremely small pressures.—On the determination of the molecular weights of gases; reply of M. Marqfoy to M. Daniel Berthelot.—On reaction zones, by M. Albert Colson.—On the phosphorescent mixtures formed by strontium sulphide, by M. J. R. Mourelo.—On the limits of inflammability of combustible vapours, by MM. H. Le Chatelier and O. Boudouard.—Spectrum analysis of some non-conducting minerals by fused salts, by M. A. de Gramont.—Synthesis of safranine, by M. Georges F. Jaubert.—Action of aluminium chloride and of chlorine in presence of aluminium chloride upon anhydrous chloral, by M. A. Mouneyrat. By the action of $AlCl_3$ upon chloral at 100°, besides the products already discovered by Combes, pentachlorethane, $CCl_3.CHCl_2$ is obtained, and the tetrachlorethylene which forms the main product of the reaction is formed from this by further heating with $AlCl_3$. With chlorine, under similar conditions, a good yield of hexachlorethane is obtained.—Estimation of phosphoric acid in superphosphates, by M. Léo Vignon.—New observations on *Peripatus*, by M. E. L. Bouvier.—On the carbon monoxide normally contained in the blood, by M. Maurice Nicloux. The amounts of gas given by the blood of animals from the country is sensibly the same as in that of animals in towns (Paris). The carbon monoxide would appear to be produced within the organism itself.—On fungi intermediate between *Tricophytons* and *Achorions*, by M. E. Bodin.—On the minerals of the basaltic fumerolles of Royat (Puy-de-Dôme), by MM. A. Lacroix and P. Gautier.—On the apatite from certain granulitic enclosures from Chuquet-Genestoux, by MM. A. Gonnard and Adelphe.—Urinary acidity and its determination, by M. Charles Lapierre.—Earthquake of May 6, 1898, communicated by M. Michel Lévy.

DIARY OF SOCIETIES.

THURSDAY, JUNE 2.

ROYAL INSTITUTION, at 3.—Modern Methods and their Achievements in Bacteriology: Dr. E. E. Klein.

LINNEAN SOCIETY, at 8.—Notes on some Lories: Prof. St. George Mivart, F.R.S.—A Revision of the Genus Symblepharis: E. J. Salmon.—On the Food of the Uropoda: Surgeon-Captain H. A. Cummins.

CHEMICAL SOCIETY, at 8.—The Action of Ether on Organic Acids and on Carbohydrates in Presence of Hydrogen Bromide: H. J. H. Fenton and Mildred Gostling.

FRIDAY, JUNE 3.

ROYAL INSTITUTION, at 9.—The Development of the Tomb in Egypt: Prof. W. M. Flinders Petrie.

GEOLOGISTS' ASSOCIATION, at 8.—Fossil Sharks and Skates, with special reference to those of the Eocene Period: A. Smith Woodward.

SATURDAY, JUNE 4.

ROYAL INSTITUTION, at 3.—The Temples and Ritual of Asklepios at Epidaurus and Athens: Dr. R. Caton.

MONDAY, JUNE 6.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Circumnavigation of Lake Bangweulu: Poulett Weatherley.

SOCIETY OF CHEMICAL INDUSTRY, at 8.—The Conditions existing in Acetylene Generators: Prof. V. B. Lewes.

INSTITUTE OF ACTUARIES, at 5.—Annual General Meeting.

TUESDAY, JUNE 7.

ZOOLOGICAL SOCIETY, at 8.30.—On some Crustaceans from the South Pacific. Part II. *Macrura anomala*: L. A. Borradaile.—Report on the Gephyrea collected by Mr. J. Stanley Gardiner at Rotuma and Funafuti: Arthur E. Shipley.—Fourth Report on Additions to the Batrachian Collection in the Natural History Museum: G. A. Boulenger, F.R.S.

WEDNESDAY, JUNE 8

GEOLOGICAL SOCIETY, at 8.—On the Discovery of Natural Gas in East Sussex: C. Dawson.—Note on Natural Gas at Heathfield Station (Sussex): Dr. J. T. Hewitt.—On some High-Level Gravels in Berkshire and Oxfordshire: O. A. Shrubsole.—The *Globigerina*-Marls of Barbados: G. F. Franks and Prof. J. B. Harrison. With an Appendix on the Foraminifera, by F. Chapman.

THURSDAY, JUNE 9.

ROYAL SOCIETY, at 4.30.—*Probable Papers*: Experiments on Aneroid Barometers at Kew Observatory and their Discussion: Dr. C. Chree, F.R.S.—The Nature of the Antagonism between Toxins and Anti-Toxins: Dr. C. J. Martin and Dr. T. Cherry.—Some Differences in the Behaviour of the Real Fluids from that of the Mathematical Perfect Fluid: A. Mallock.—On the Heat Dissipated by a Platinum Surface at High Temperatures: J. E. Petavel.

ROYAL INSTITUTION, at 3.—Modern Methods and their Achievements in Bacteriology: Dr. E. E. Klein.

MATHEMATICAL SOCIETY, at 8.—On the General Theory of Anharmonics: Prof. E. O. Lovett.—Point-Groups in a Plane, and their Effect in determining Algebraic Curves: F. S. Macaulay.—On a Regular Rectangular Configuration of Ten Lines: Prof. F. Morley.—On the Calculus of Equivalent Statements (eighth paper): H. MacColl.

FRIDAY, JUNE 10.

ROYAL INSTITUTION, at 9.—Some Experiments with the Telephone: Lord Rayleigh.

ROYAL ASTRONOMICAL SOCIETY, at 8.

MALACOLOGICAL SOCIETY, at 8.

SATURDAY, JUNE 11.

ROYAL INSTITUTION, at 3.—The Temples and Ritual of Asklepios at Epidaurus and Athens: Dr. R. Caton.

GEOLOGISTS' ASSOCIATION (Waterloo Station, S.W.R.), at 1 50.—Excursion to Godalming. Director: T. Leighton.

BOOKS, PAMPHLET, and SERIALS RECEIVED.

BOOKS.—City and Guilds of London Institute. Report of the Governors, March 1898 (Gresham College).—A Text-Book of Entomology: Prof. A. S. Packard (Macmillan).—Britain's Naval Power: H. Williams, Part 2 (Macmillan).—The Pruning Book: L. H. Bailey (Macmillan).—A Primer of Psychology: E. B. Titchener (Macmillan).—Weather Lore: R. Inwards, 3rd edition (E. Stock).—Ackworth Birds: Major W. B. Arundel (Gurney).—Elementary Practical Zoology: F. E. Beddard (Longmans).—Outlines of Sociology: L. F. Ward (Macmillan).—A System of Medicine: edited by Prof. T. Clifford Allbutt, Vol. v. (Macmillan).—Through Unknown Thibet: Captain M. S. Wellby (Unwin).

PAMPHLET.—Remarkable Eclipses: W. T. Lynn, 3rd edition (Stanford).

SERIALS.—Psychological Review Monograph Supplements, Vol. 2, No. 3 (Macmillan).—Longman's Magazine, June (Longmans).—Sunday Magazine, June (Isbister).—Good Words, June (Isbister).—Chambers's Journal, June (Chambers).—Publications of the British Fire Prevention Committee, Nos. 1 to 7 (1 Waterloo Place).—Humanitarian, June (Hutchinson).—Sitzungsberichte der Physikalisch-Medicinischen Societät in Erlangen, 29 Heft, 1897 (Erlangen).—Natural Science, June (Dent).—Century Magazine, June (Macmillan).—Notes from the Leyden Museum, July and August, 1897 (Leiden, Brill).—National Geographic Magazine, May (Washington).

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