Nature

A WEEKLY

ILLUSTRATED JOURNAL OF SCIENCE

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VOLUME LXXXIII

MARCH to JUNE, 1910

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

London
MACMILLAN AND CO., LIMITED
NEW YORK: THE MACMILLAN COMPANY

Richard Clay and Sons, Limited,
bread street hill, e.c., and
bungay, suffolk.

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REVIEWS AND OUR BOOKSHELF.

NATURE

A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE.

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

THURSDAY, MARCH 3, 1910.

AN ENCYCLOPÆDIC TREATISE ON THE PROTOZOA.

Lehrbuch der Protozoenkunde. Zweite Auflage der "Protozoen als Parasiten und Krankheitserreger." By Dr. F. Doflein. Pp. x+914; 825 figures. (Jena: Gustav Fischer, 1909.) Price 24 marks (unbound).

THE study of the Protozoa has made very great progress during the last twenty years, so great that even those who devote themselves to this branch of knowledge have the utmost difficulty in keeping pace with its rapid advance. This state of things is due chiefly to the great practical importance of the Protozoa for medical, veterinary, and agricultural science, but also because the primitive forms of life give the clue to many biological problems of fundamental importance. Hence the number of those who occupy themselves with researches upon Protozoa has very much increased, both amongst professed zoologists and also amongst those to whom zoological questions are a secondary consideration; all such workers, however, whatever their aims, will welcome the publication of Prof. Doflein's treatise. This work is ostensibly the second edition of his well-known manual on the Protozoa as parasites and causes of disease, a most useful book in its time, though now left behind by the flowing tide of research; its parentage, however, is scarcely recognisable, since the second edition appears with new title, changed form, and greatly enlarged scope. The treatment of parasites and disease, though not neglected, takes a secondary place, and the work has become an exhaustive general treatise on the Protozoa.

It is difficult, within the limits of space imposed upon a reviewer, to give an adequate account of the wealth of facts, ideas, and illustrations contained in the 900 or so pages of this book. The work is divided into two halves, the first containing a general account of the natural history of the Protozoa, the second a more detailed systematic description of the groups of Protozoa and of the special problems connected with them.

The general part begins with a short introduction giving the definition and distinctive characters of the Protozoa, and is then subdivided under the headings morphology, physiology, reproduction, biology (or bionomics), system, and technique. The Protozoa are regarded as unicellular organisms occupying a middle position between the Bacteria and their allies below and the Metazoa above. As regards the structure of protoplasm, the author is a strong adherent of the alveolar theory of Bütschli. The nucleus of Protozoa is described in detail, both as regards constitution and morphology, and special sections are devoted to chromidia, centrosomes, and blepharoplasts; we miss, however, any discussion of the binuclear hypothesis of the cell, put forward by Hartmann and Prowazek, in relation to the theory of the centrosome. The term "blepharoplast" is applied by the author to the kinetonucleus of trypanosomes, as is usual in Germany; we must confess to a feeling of surprise, however, that the author doubts the nuclear nature of this body.

The section on physiology is subdivided under the headings "Stoffwechsel" and "Kraftwechsel." The section on reproduction deals with fission, fertilisation, form and development, the Protozoa as unicellular organisms, and theoretical problems of sex and reproduction. Under the fifth of these headings the author discusses the hypothesis of nuclear dualism (more correctly dualism of the chromatin-substance) of the protozoan organism put forward by Schaudinn and Goldschmidt; according to this view, every protozoon is be regarded as containing two nuclei (or rather two kinds of chromatin), a "Stoffwechselkern" of vegetative somatochromatin, and a "Geschlechtskern" of generative idiochromatin. The author considers (and we fully agree) that there are not two distinct kinds of nuclear substance, but that one and the same substance is responsible both for functional activity and for heredity in the protozoan body; he quotes Hertwig's opinion in support of his own, to the effect that somatochromatin is idiochromatin of which the activities are awakened, and idiochromatin is somatochromatin in which the activity is dormant but can be renewed under suitable conditions. He considers, further, that many substances, which have been mistaken for chromatin on account of their affinity for stains, are in reality reserve materials, precipitation-products, and the like, and that this confusion of chromatin with other substances has often led to the erroneous distinction of two kinds of chromatin.

In discussing the theoretical aspects of reproduction and fertilisation, the author states and reviews in a very clear and interesting manner the various theories that have been put forward, especially those of Weismann, Bütschli, Hertwig, and Schaudinn, and ends by sketching in brief outline a theory of his own. Living cells are regarded as consisting principally of two groups of vitally-active substances, the one, more fluid, responsible for motor phenomena, the other, more viscid, regulating metabolic cell-functions. In cell-reproduction by fission these substances are never distributed with mathematical equality amongst the descendants, hence continued division brings about accumulations of different properties in certain individuals, with, as a consequence, impaired vital activity and reproductive power. Individuals are produced, some of which become richer in reserve material (female), others in motile substance (male). Since these two kinds of individuals contain aggregations of substances which have intense mutual chemical reactions, they exert an attraction one towards the other; the two individuals tend to unite as gametes, and by their union cell-equilibrium is restored and vital powers renewed. Hence fertilisation is regarded as a necessity for the life-cycle, due primarily to the imperfections of cell-division and to the consequent loss of equilibrium in the cell-constituents, a view which unites and extends the theories of Schaudinn and Hertwig respectively.

The section dealing with the bionomics of the Protozoa is divided into the following subsections:—occurrence and distribution, habit and mode of life, adaptation of the methods of nutrition, adaptations of the reproductive processes and means of dispersal, influence of the medium, light and rays, temperature and climate. Under the heading "System," the various classifications that have been put forward are discussed. The Protozoa are classified into two main divisions, first, the Plasmodroma, including the Rhizopoda, Mastigophora, and Sporozoa; and, secondly, the Ciliophora, including the Ciliata and Suctoria. The Spirochætes are regarded as leading from the organisms of bacterial nature to Mastigophora, and hence, for the first time, we believe, in a treatise on Protozoa, the Mastigophora are dealt with before the Rhizopoda.

The section on technique is a brief summary of methods of cultivating, investigating, and preserving Protozoa.

The special part of the work is a detailed description, in systematic order, of the structure and life-histories of the orders, families, and more important genera and species of Protozoa. Intercalated amongst the systematic descriptions are sections dealing with the parasitic and pathogenic importance of certain groups, namely, the Spirochætes, Flagellates, Amœbæ, and Telosporidia. In these sections the diseases produced by the Protozoa in question, and their pathology and etiology, are discussed, with figures and descriptions of the blood-sucking invertebrates which are responsible for their dissemination. From all this wealth of material we must be content to note a few points concerning debated questions. The theory of an alternation of sexual and non-sexual generations in trypanosomes, comparable to the alternating cycles of Hæmosporidia, is regarded as purely hypothetical and in need of proof. The author considers that it will probably be necessary in the future to place the genus Trypanosoma in the family Cercomonadidæ, in close proximity to Herpetomonas and Crithidia; on the other hand, Trypanoplasma is placed in a separate family, Bodonidæ. Schaudinn's statements with regard to the relationship of Trypanosoma to Hæmoproteus and Leucocytozoon are set forth in detail, together with the criticisms and objections of Novy, MacNeal, and others; judgment is suspended until more exact information shall have been obtained, but Hartmann's union of Hæmosporidia and Trypanosomes into one group, the Binucleata, is not accepted. The genus Hæmoproteus (Halteridium) is dealt with in an appendix to the Hæmosporidia, together with Babesia, Endotrypanum, and Leishmania; it will be a surprise to most protozoologists to meet with Leishmania in this company, and we are decidedly of opinion that its proper position is in the neighbourhood of Herpetomonas.

In the class Rhizopoda the forms with lobose pseudopodia and a shell are placed with the monothalamous Foraminifera, so that this order can no longer be defined by the reticulose nature of its pseudopodia. The Protomyxidea, including the genera Vampyrella, Pseudospora, Chlamydomyxa, and Labyrinthula, are placed as an appendix of uncertain position at the end of the Rhizopoda.

The Telosporidia are subdivided into Gregarinidæ and Coccidiomorpha; the second of these divisions includes the Coccidia and the Hæmosporidia, which are divided into Plasmodidæ and Hæmogregarinidæ. We regret to see the familiar generic name Coccidium replaced by Eimeria; this is one of those many cases where, in our opinion, rebellion against the law of priority in nomenclature is not only lawful but imperative.

The feeling aroused by even a cursory scrutiny of this book is one of dismay at the vast extent to which the subject has grown, astonishment at the erudition of the author, and gratitude to him for his painstaking diligence in putting together such a store of important facts and so useful a guide to the intricacies of the subject. It would not be difficult, perhaps, to point out parts of the book here and there in which certain subjects or groups have not been so well treated as others; the Hæmogregarines, for instance, are not dealt with very adequately. But a treatise of this size, on which the carping critic would be perforce silent, could hardly have been written by a human being, or even by several. It is seldom that so great a work is completed by one man at the present time. A striking feature of the book is the number of beautiful illustrations, and especially of previously unpublished figures, some by the author and some by other investigators; in particular we would direct attention to many figures reproduced from those left behind by the late Dr. Fritz Schaudinn, which will be of the greatest interest to all protozoologists.

In conclusion, we have no hesitation in recommending this work to all those who wish to possess an admirable and exhaustive treatise on the Protozoa.

E. A. MINCHIN.

THE EARLY HISTORY OF NEW ZEALAND.

Murihiku, a History of the South Island of New Zealand and the Islands adjacent and lying to the South, from 1642 *to* 1835. By Robert McNab. Pp. xv+499; with plates and charts. (Wellington, N.Z.: Whitcombe and Tombs, Ltd., 1909.)

THOSE who are personally acquainted with that prosperous and very up-to-date portion of His Majesty's Empire now known as the Dominion of New Zealand will find it difficult to realise that so recently as the year 1835 the Customs House authorities in London decided that whale oil imported from that country was liable to a duty of 26*l.* 12*s.* per tun, on the ground that it did not come from a British possession. So many stirring events, however, had already taken place in New Zealand at this date that it has required eleven years of research to enable Mr. McNab to recover from the "forgotten past" the materials for a history of the southern portion of the Dominion from the time of its discovery by Tasman in 1642 up to the year mentioned. The task has been an arduous one, involving the close study of rare works in English, Spanish, French, and Russian, and the examination of countless official documents and files of local newspapers. Information has been brought together from every quarter of the globe, and not the least interesting of the author's discoveries is that of a series of manuscript logs of early voyages, which he found in the library of the Essex Institute at Salem, Massachusetts.

The classical explorations of Tasman, Cook, and Vancouver are already familiar to students of history, but the details of Bellingshausen's visit have hitherto been almost unknown to English readers. He commanded a Russian expedition which reached New Zealand in 1820. The narrative of the voyage, published in Russian, is now very rare. An abridged translation was published in German in 1904, and Mr. McNab has included in the present volume an English translation of the portions relating to New Zealand, the most interesting of which is a graphic account of the sea-elephant fishery which then flourished in Macquarie Island.

In the early part of the nineteenth century New Zealand and the adjacent islands were a kind of no-man's-land, and a happy hunting-ground for sealers and whalers from Australia and America. The records of these early trading expeditions, culled largely from the shipping reports and correspondence columns of the Sydney newspapers, contain much of thrilling adventure. The men must have been made of stern stuff who would consent to be left behind in small sealing gangs on an almost unknown coast, exposed to the attacks of the cannibal Maoris—attacks which were sometimes very successful—and with scanty supplies, while their ship continued her explorations, to call for them and their sealskins at some future date, often many months later. Sydney formed the headquarters of most of these expeditions. It was then a convict settlement, and we are told that Governor Phillip actually asked the English authorities for special powers to deport condemned men to New Zealand to be handed over as food for the natives!

The compilation of this work has evidently been a labour of love, but the author has none the less earned our gratitude by the manner in which he has fulfilled his task. Ethnologists and naturalists will both find a good deal to interest them in the book, but it is as a piece of historical research that it must be judged, and we expect that the writer of historical romance, as well as the more serious student of history, will profit largely by it in years to come.

A. D.

CHEMICAL CONTROL OF FOODSTUFFS.

Food Inspection and Analysis. For the use of Public Analysts, Health Officers, Sanitary Chemists, and Food Economists. By Albert E. Leach. Pp. xviii+954+xl plates. Second edition, revised and enlarged. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd., 1909.) Price 31*s.* 6*d.* net.

THIS work, the first edition of which was reviewed in these columns some four years ago (NATURE, November 17, 1904, p. 57), is favourably known in this country as a very useful aid in the analysis of foodstuffs. For the information of readers interested in this subject and hitherto unacquainted with the volume, we may mention that it aims at giving, in a compass of about a thousand pages, a short description of the origin and composition of all the chief foods, condiments, and alcoholic beverages; together with a selection of the most approved methods for their chemical and physical examination.

General laboratory equipment is dealt with, and there are sections devoted to special apparatus, such as the microscope, camera, tintometer, refractometer, and polarimeter. Numerous tables of analytical constants are provided, as well as many illustrations of microscopical structure; in fact, the idea appears to be to make the book so far as possible self-sufficient for all ordinary work. The convenience of this is obvious; the essential information, enabling routine samples to be disposed of, is collected in one volume instead of being scattered over half-a-dozen. For assistance in dealing with special cases, where fuller details are necessary, a long list of references is appended to each chapter.

The new matter in the second edition runs to some 167 pages. A notable extension is made in the chapter devoted to cereals. Here we remark the inclusion of such matters as the use of pancreatin for starch-converting purposes alternatively to malt extract; a table (Kröber's) for determining pentoses and pentosans from the amount of phloroglucide; a scheme for complete ash-analysis, and sections dealing with the bleaching and examination of flour. These last, in addition to the usual methods for determining the proportions of gluten, gliadin, and other proximate constituents of flour, include descriptions of baking-tests, absorption and dough-tests, and the two best-known means of recognising bleached flour, namely, extraction of the colouring matters with light petroleum, and the detection of nitrites in the sample.

An extension which will be found very useful is a separate chapter upon the examination of flavouring-extracts and their substitutes. Processes are given for the determination of vanillin, coumarin, benzaldehyde, lemon oil, wintergreen oil, and other essential oils occurring in extracts and essences; and notes upon adulterants and imitations are also included.

It will be readily understood that with so large a field to cover a single volume does not, even with a thousand pages, suffice for any exhaustive discussion of the various topics. The really difficult cases of adulteration, the doubtful "border-line" problems, remain always dependent for their solution upon the experience, skill, and wider knowledge possessed by the analyst. Beyond this general observation, however, there is little but praise to bestow upon the book. Apart from one or two misprints, the only questionable matter noticed is the Defren's table on pp. 595–7, where the values of lactose appear rather doubtful; and one may claim a little grumble at the pounds avoirdupois; the book is not, in the literal sense, likely to be a *vade mecum.* It will lie on the laboratory table, but it will be worth its place there. C. S.

THE MOVEMENTS OF CHROMATOPHORES IN PLANTS.

Die Gestalts- und Lageveränderung der Pflanzen-Chromatophoren. By Dr. Gustav Senn. Pp. xv +397. (Leipzig: W. Engelmann, 1908.) Price 20 marks.

CHROMATOPHORES in plants were for long regarded as merely temporarily differentiated fragments of the cytoplasm, and, even within the present decade, were viewed as cell-organs the physiological behaviour of which is largely or mainly determined by the general protoplasm; but more recent investigations have increasingly led botanists to regard chromatophores, not only as morphological individuals—so to speak—within the cell, but also as physiological organisms in the energid. The climax of this view is the suggestion that chromatophores are in phylogeny nothing more than descendants of parasitic green organisms which entered into symbiosis with cells not possessing chlorophyll. Though this extreme hypothesis is not favoured by Dr. Senn, the evidence which he supplies causes him to conclude that chromatophores have larger powers of active contractility and more varied irritability than has hitherto been believed. He concludes that their change of shape and movements in the cell are exclusively or mainly the result of their own special activity, and that they are not passively distorted or transported by the cytoplasm (though he naturally admits their passive carriage by rotating protoplasm and the like).

The book begins with the consideration of the change of shape of the individual chloroplast, a phenomenon generally neglected by botanical teachers, though easily visible in such familiar laboratory types as Funaria and Vaucheria. Dr. Senn describes the changes of shape in a number of types, and discusses the parts played in causing them by light, temperature, and chemical and other agencies. His general conclusion is that change of shape of the chromatophore is occasioned by "diffuse," not directive stimuli.

The main mass of the book deals, however, with changes in position of the chromatophores in the cell. Eight different patterns of distribution are recognised —epistrophe, apostrophe, systrophe (round the nucleus), peristrophe (uniformly round the cell-walls), antistrophe (on the wall facing the light), diastrophe (on the wall facing the light and on that opposed to it), parastrophe (in shaded parts of the cell), and escharostrophe (at the focus of the rays of light entering the cell). The conclusion is drawn that change of position of the chromatophores in the cell is the result of "tropic tactic [taxis] stimulus," in which the direction of the stimulus (for instance, light) does not as such determine the result, but only does so indirectly by involving a difference in intensity. According to Dr. Senn the distribution of the chromatophores in the cell is not the result of a simple stimulus emanating from the general protoplasm or released by differences in turgidity, but is the consequence of several types of irritability (phototaxis, chemotaxis, thermotaxis, osmotaxis) possessed by the chromatophores, which thus react in the same manner as free zoospores or Protozoa.

An appendix treats of the refractive index of the plant cell.

In a brief notice it is impossible to do justice to the wealth of detail in the book, which, except in the case of the special investigator, is one to be consulted rather than read through; indeed, the present reviewer confesses that he has not read the whole of the 376 pages of text.

Apart from containing the results of prolonged research and numerous observations, this critical book derives value from the thorough manner in which the author considers and does justice to the work of his predecessors, also from the repeated summaries of the conclusions arrived at concerning the various problems investigated, and from the rich bibliography and excellent index. The book, in fact, is one that should at least be in the library of every botanical institute.

MODERN ALGEBRA.

(1) *A New Algebra.* By S. Barnard and J. M. Child. Parts i.–iv., with answers. Pp. x+534. Price 4*s.* Part iv., with answers. Pp. x+(301–466). Price 1*s.* 9*d.* (London: Macmillan and Co., Ltd., 1909.)

(2) *College Algebra.* By Dr. S. C. Davisson. Pp. ix+191. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1909.) Price 7*s.* 6*d.*

(1) FEW branches of elementary mathematics have escaped the hand of the reformer during the last ten years. That this is a healthy symptom is unquestionable, for at least it points to a revival of interest, which cannot but infuse fresh life into a subject that the monotony of time may render arid and perfunctory. What measure of favour is to be

accorded to each set of changes must necessarily depend on the view that is taken of the purpose of a mathematical training in our educational system. It is not easy to form a combination of what is useful with what is interesting; and still less is it a simple matter to determine how far it is judicious to discuss at an early stage the fundamental ideas which underlie each branch of mathematics. But at the present time we believe that there is a dangerous tendency to pass over all considerations of mathematical philosophy as too difficult or uninteresting. We therefore welcome the present volume, which is a real attempt to build up an elementary course of algebra on the fundamental concepts of number and the operations to which it is subject.

The book is divided into four parts; the first deals with positive numbers, the second with zero and negative numbers, the third with irrationals, and the last with the more advanced applications, such as simultaneous quadratics, proportion, progressions, and the variation of simple functions. Each new idea that occurs is explained at considerable length in the text with admirable clearness, and is usually illustrated by graphical examples. In practice, no doubt, this will be used as the substance of an oral treatment, for few pupils will be sufficiently mature to be able to read and assimilate it unaided. There are abundant examples, a useful number of test papers, and an index which should prove of great practical value. We hope that this book will be widely used, for its principles are sound, and it introduces the student to a number of ideas that are both stimulating and instructive.

(2) This volume is intended to be used for a revision course. Stress is therefore laid on such features of the subject as are apt to be dealt with rather cursorily, or even omitted during the first reading. At the same time, however, the plan of the book is not designed to meet the wants of the professional mathematician, but to suit those who need a reasonably complete knowledge of the elementary principles of algebra. The remainder theorem and the principle of undetermined coefficients are placed in an early chapter; the section on linear equations contains also the fundamental properties relating to the roots of equations of any degree; and the theory of simultaneous equations is expanded to include an elementary account of the use of determinants. By such means as these, the author has provided a course which is admirably adapted for a second reading. The treatment is fresh and vigorous, the explanations are clearly put, and great care has been taken to ensure that the student really understands the nature of the various operations which he is called upon to perform.

OUR BOOK SHELF.

Les Tremblements de Terre. By l'Abbé Moreux. Pp. vii+378. (Paris: Henri Jouve, 1909.) Price 4 francs.

ON June 11, 1909, towns in south-eastern France, and particularly those in the district of Provence, were shattered by an earthquake. The places which suffered most were Salon, Lambesc, Saint-Cannat, Rognes, and Le Puy-Sainte-Réparade. Roughly speaking, the damage done to structures was estimated at 16,000,000 francs, which means something more than half a million sterling. From a monetary point of view this is a large sum, and it no doubt represents the effects of an unusually large earthquake. Had a similar rock adjustment taken place beneath a large city this sum would have been greatly magnified. The damage at San Francisco has been estimated at 70,000,000*l.* sterling. Naturally, the disaster excited the imagination, and survivors have speculated on the cause of earthquakes. One outcome of the thoughts which were so rudely created is the book by the Abbé Moreux.

The author has read much about earthquakes. At the outset, although he tells us that his writings are not addressed to specialists, he has taken pains to popularise speculations about which specialists have but slight knowledge. He gives us a series of pictures of the ruins, tells us about the heartrending cries of the people, the arrival of the doctors, the erection of huts, and the generosity of the Pope. Next we read about possible premonitory signs. We are told that before the earthquake people suffered from vertigo, clocks struck wrongly, whilst pigeons flew about rather than going to rest. One interesting picture, which is not unlike the Cullinan diamond, is that of our pyramidal earth, the fourth corner of which was found by Sir Ernest Shackleton.

Reference is made to recent investigations relating to seismology, from which we learn that our world has a rigidity double that of steel. Volcanic and seismic effects are not directly connected, but earthquakes are in part the result of tectonic adjustments. They hold a relationship to the wobbling of the pole, fluctuations in barometric pressure, the change of seasons, lunar and solar attractions, and to internal convection currents. Earthquakes explain certain perturbations of magnetic needles and earth currents, whilst they are closely associated with solar radiation. The periodicity of earthquakes and their prediction are subjects which are not overlooked, whilst many pages are devoted to construction in earthquake countries, and to the mitigation of disasters. The relationship of pressure to temperature as we descend in the earth, and the fact that bodies may during crystallisation, or when they pass from the fluid to the solid state, suddenly expand, are phenomena which the Abbé discusses at considerable length. In fact, we are told that the shock accompanying such expansions may be the principal cause of many earthquakes.

It is an interesting little book, and will furnish many with subjects for speculation which have never crossed their minds before. J. MILNE.

The Methods of Textile Chemistry, being the Syllabus of a Lecture Course adapted for use in Textile Laboratories. By Dr. F. Dannerth. Pp. viii+164. (New York: John Wiley and Sons; London: Chapman and Hall, Ltd., 1908.) Price 8*s.* 6*d.* net.

IF the author had employed the title "Some Methods of Textile Chemistry" in place of the one he has chosen he would have erred on the right side. But to attempt to deal with the whole subject of textile chemistry—one of the most difficult and involved branches of analytical chemistry—in 120 small octavo pages of large type can scarcely result in anything of real value, even if the work is done as well as it is possible to do it. But when, as in the present case, the information is badly arranged, containing much that is superfluous if not useless, while omitting many matters of fundamental importance, and is not without a liberal sprinkling of mistakes and inaccuracies, the inevitable result is a dismal failure. It is not quite clear for what class of reader the work is really intended, for in the preface we read that it "is intended to be a source of information and ready reference for the textile chemist," while on the title-page it would appear from the continuation of the main title, "being the syllabus of a lecture course adapted for use in textile laboratories," that it might be intended for some other purpose, possibly for teaching. In either case it has missed its mark.

These "knowledge in a nutshell" publications on technical chemistry, of which there appears to have been an increasing supply of late years, may be just the sort of thing that please people who like that sort of thing, but although there are a few exceptions, it is doubtful whether they do much good, while, on the other hand, they may do distinct harm through creating, under pretentious titles, a totally misleading impression of the subject as it presents itself in actual practice.

Naturwissenschaftliches Unterrichtswerk für höhere Mädchenschulen. By Prof. Dr. K. Smalian. Auf Grund der Bestimmungen vom 19 December, 1908, über die Neuordnung der höheren Mädchenschulwesens in Preuszen bearbeitet von K. Bernau. II Teil: Lehrstoff der VI Klasse. Pp. 80. Preis 1.80 marks. III Teil: Lehrstoff der V Klasse. Pp. 127. Preis 2.25 marks. (Leipzig: G. Freytag; Vienna: E. Tempsky, 1909–10.)

IN the early part of last year a notice appeared in NATURE of Dr. Smalian's "Leitfaden der Tierkunde für höhere Lehranstalten," a work comprising a zoological text-book in separate fasciculi intended for the use of the various classes in German high schools. The fasciculi now before us form part of another work designed on somewhat similar lines for the use of girls' schools, but including botany as well as zoology. The general commendation bestowed on the "Leitfaden" may be extended to the present text-book, with the addition that we have little fault to find with the coloured plates of animals, while those of plants are excellent examples of German colour-printing, and worthy of all praise. Each of the two fasciculi now before us is divided into a botanical and a zoological portion; and it may be presumed that the same holds good for the other portion of the series. The zoological section of the second fasciculus is devoted to vertebrates, and that of the third to arthropods. A number of well-known species of mammals are, however, described in the first fasciculus.

The general plan of the work is similar to that of the "Leitfaden," the various orders being treated in systematic order, and a certain number of typical species being selected for comparatively full notice, while other groups are treated more briefly. In the case of the species selected as types, leading features in the external form and structure and noticeable traits in the matter of habits are touched upon; and throughout the work technicalities are, so far as possible, avoided. The only scientific names introduced are those of species, ordinal and family groups being referred to by vernacular designations. In the main the species represented in the illustrations seem to be correctly named; but in one of the coloured plates the monkey designated *Cercopithecus sabaeus* is clearly *C. aethiops* or one of the allied forms, as it has the distinct white brow-band of the latter, which is absent in the former. So far as we can see, the book appears admirably suited for its purpose, although it by no means follows that it would be equally well adapted to the needs of English schools.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Meaning of "Ionisation"

IN asking for precision of language (p. 487), Prof. Armstrong shows how much he has fallen behind his time. If he had kept abreast of the recent developments of the principles of science, he would know that to be precise means running the risk of being wrong, which is to be avoided at all costs. Prof. Armstrong evidently belongs to an antiquated school which believed that scientific discoveries are made by forming definite ideas of things, even though these cannot be seen and handled. That is a standpoint which is abandoned, and we have entered on a new era. Science now aims purely at obtaining an equation which, without committing itself to any definite views, gives the required relationship between the brain impressions taking place in that particular dimension of a many-dimensional complex, which we identify with time. I am sorry if in this statement I have committed myself to the existence of a brain—it was lapse due to a weak concession to the prejudices of my youth, and would have been impossible in a thorough-going adherer to the new faith.

But to come to the point. If Prof. Armstrong will bring the theory of entropy to bear on the principle of least resistance to a cheap appearance of sagacity, he will discover, not what Arrhenius meant by ionisation—that is unimportant—but what he ought to have meant and would have meant if he were a chemical physicist such as we make them now.

A. S.

The Fertilising Influence of Sunlight.

THE letter on the above subject by Mr. and Mrs. Howard in NATURE for February 17 raises a question of much scientific interest and of considerable importance in tropical agriculture. In some of the text-books it is stated that the hot sunshine of tropical or subtropical climates must injure the productiveness of the soil, since it kills bacteria. On the other hand, experiments on the partial sterilisation of soil by other means—such as heat or volatile antiseptics—shows that the killing of bacteria (as distinct from spores) leads to an increased, and not a diminished, productiveness. The apparent discrepancy is now cleared away, and we have Mr. and Mrs. Howard's authoritative statement that strong sunlight has beyond question a beneficial effect on productiveness.

There is a close resemblance between the effects they describe and those that have been obtained with partially sterilised soils by myself in conjunction with Dr. Darbishire and with Dr. Hutchinson; in all cases the effect is that of a dressing of nitrogenous manure. Dr. Hutchinson and I have traced this to an increased rate of decomposition of organic matter after partial sterilisation, and have shown that the increased activity is due to the destruction of some agent, probably large organisms, which had previously interfered with bacterial development. The question is, Could sunlight partially sterilise a soil and kill the large destructive and competing organisms that we suppose limit productiveness?

There are at least three factors involved: sunshine dries the soil, heats it to a certain temperature, and may have a direct chemical action fatal to the cell. We are at present studying the effect of dryness and of temperatures lower than 100° (at which we have previously worked), but the direct effect of sunshine is not easily investigated here. Some preliminary experiments I made at Wye during the summer of 1906 indicated that soil exposed to bright sunshine for a period of ten days subsequently absorbed oxygen more rapidly, *i.e.* showed a higher rate of bacterial activity, than another lot kept shielded from the light. The effect was comparable with that produced by volatile antiseptics, and, so far as the experiment goes, it shows that sunlight could, equally with these, remove the factor limiting productiveness in ordinary soils. I have several times attempted to extend the experiment, but have been unfortunate in timing it, and have missed the continuous spells of strong sunshine.

We could not hope to attack the problem so successfully here as in India, and it would be interesting to have some Indian work on the subject. The experiments of Mr. and Mrs. Howard in conjunction with Mr. Leake on the "fertilising influence of sunlight" may be expected to throw a great deal of light on a very important problem.

E. J. RUSSELL.

Rothamsted Experiment Station, Harpenden.

The Spectrum of Bacterial Luminosity.

IN the course of some experiments on the phosphorescence of minerals, especially with regard to the emission of ultra-violet radiation, it was suggested to me by Prof. Strutt that it would be of interest to examine the spectrum of the light from luminous bacteria. Through the kindness of Sir James Dewar, Prof. Strutt was enabled to furnish me with a dish containing bacteria produced from fish which, when viewed in a darkened room, were seen to glow with a greenish-blue light bright enough to enable one to read a watch. The dish was placed in front of the slit of a quartz spectrograph of rather crude design, constructed with lenses of short focal length so as to utilise the light available to the fullest extent. A special rapid photographic plate was first exposed to the radiation from the bacteria for forty-six hours, and then to the light from a cadmium spark for one second.

The plate when developed exhibited strong evidence that the spectrum of the light emitted by the bacteria consisted of a continuous spectrum extending from wave-length 5000 (the lower limit of the sensitiveness of the plate) to wave-length 3500 tenth-metres, together with a well-marked bright band of wave-length 4000 approximately. Practically the same result has been obtained from bacteria produced from meat. The greater portion of the radiation is absorbed by a film of nitroso-dimethylaniline.

Mr. J. E. Barnard, in his article on luminous bacteria (NATURE, April 10, 1902), states that the light emitted by these organisms is confined to a small portion of the visible spectrum, and never extends into the ultra-violet or infra-red. The photographs I have obtained indicate that in some cases these bacteria emit ultra-violet radiation, and I hope with another spectroscope, now in course of construction, to obtain more definite information.

R. W. FORSYTH.

Royal College of Science, South Kensington, S.W., March 1.

Self-fertilisation and Loss of Vigour.

SOME of your readers will remember that in the introduction to "Cross and Self-fertilisation of Plants," Darwin inserts a report by Sir Francis Galton on seven tables of measurements relating to the relative heights of the offspring of cross and self-fertilised plants. "It is a very remarkable coincidence," says Galton, "that in the seven kinds of plants the ratio between the heights of the crossed and the self-fertilised ranges in five cases within very narrow limits. In *Zea mays* it is 100 to 84, and in the others it ranges between 100 to 76 and 100 to 86."

If Table A of Darwin's book be referred to, it will be found that these ratios recur in many more than five cases. I write to suggest—with great diffidence, as I am a mere amateur in such matters—that the persistence of these ratios is capable of simple explanation on the basis of the Mendelian theory of heredity.

The distribution or "array" of a Mendelian family, crossed at random, is given by the expansion of $(3D+R)^n$, where n = the number of pairs of characters involved, and the powers of D and R respectively represent the number of dominant and recessive somatic characters of each individual. If, now, each individual be self-fertilised, the array can be shown by simple algebra to become $(5D+3R)^n$. Similarly, in the next self-fertilised generation, the array becomes $(9D+7R)^n$, and so on. The average number of dominant characters in each generation is, consequently, $\frac{3}{4}n$; $\frac{5}{8}n$; $\frac{9}{16}n$, &c., which give the ratios 100 : 83 : 75, &c.

It is surely something more than a "remarkable coincidence" that these ratios agree in so many cases with the ratios observed by Darwin?

A. B. BRUCE.

School of Agriculture, Cambridge, February 19.

Vision and Colour Vision.

WITH reference to the comment on my lecture at the Royal Society of Arts in NATURE of February 17, I did not give the evidence in favour of the visual purple being the visual stimulus transformer on account of the time at my disposal. This evidence is very strong, and the facts are inexplicable on any other hypothesis. Many physiologists have tried to assign different functions to the rods and cones, but these theories have failed because all the functions which were said to be the exclusive property of the rods have been found, only gradually diminished, in the fovea, in which only cones are present. For instance, von Tschermak, Hering, Hess, Garten, and others, have found the Purkinje phenomenon, the variation in optical white equations by a state of light and dark adaptation, the colourless interval for spectral lights of increasing intensity, the varying phases of the after-image, in the fovea, only gradually diminished. The complete absence of any qualitative change between the foveal and extra-foveal regions is a very important fact in support of the hypothesis that the visual purple is the visual substance. There is also the fact, mentioned by Helmholtz, that a perceptible interval elapses before we see with the fovea, after the rest of the retina, when the eye has been previously some time in darkness. Hess has also pointed out that the recurrent image is present, but retarded at the yellow spot. All these observations and many others agree with my statement that the visual purple can be seen between but not in the cones of the fovea.

F. W. EDRIDGE-GREEN.

Hendon, February 19.

The Methods of Bird Fanciers.

MAY I ask for information on the following matter?

Happening to be walking in a poor quarter of Acton (Chiswick) with a friend, we were astonished to see hanging outside a house, on either side of the door, two small bird-cages completely enveloped with dark cloths carefully fastened. The cages evidently contained birds, for from one of them came the song of a chaffinch.

Had the birds suffered the torture of having their eyes put out to make them sing, or is this a method resorted to instead of blinding them?

The caging of wild birds is so very cruel that it should be exposed in all its barbarous ways.

Some of the wild birds are kept in such small cages that there is scarcely room for them to turn round.

E. L.

IT is customary for bird fanciers amongst the lower classes to match one chaffinch against another, often in public-houses, the bird which sings the largest number of notes being adjudged the victor. When the cages are carried about they are usually wrapped up in dark cloths, and it is said that one of the objects of keeping the birds in the dark is that they should imagine it is night while they are covered, and that on the cloth being removed, thinking it is day, they burst forth into song. As it is believed by some that birds sing better when they are blinded, it may be, as "E. L." suggests, that the covers were used in the case mentioned either to avoid practising the cruelty of putting out the birds' eyes or so that the fancier might not render himself liable to the punishment for doing so. More likely the birds that were kept covered were newly caught, and the object was to prevent them from dashing themselves against the bars of the cages in their endeavours to escape. As has often been pointed out, one reason for the smallness of the cages used is to lessen the danger of the birds killing themselves, as in a larger space they could begin to fly and would strike with greater force.

WILFRED MARK WEBB.

Title of the Natural History Museum.

IN NATURE of February 24 (p. 489) Mr. Hobson suggests as both "suitable and adequate" that it should be called the "British Museum of Natural History."

Why not omit "British" and "of," re-arrange the order of the words, and call it "The Natural History Museum," adding "London" if necessary?

Torquay. F. HOWARD COLLINS.

NORTH POLAR OCEANOGRAPHY.[1]

A HANDSOME volume full of useful information has been given to oceanographical science by H.R.H. the Duke of Orleans, the result of a cruise in the Greenland Sea during the year 1905. This is one of a series of Arctic cruises His Highness has been making for a number of years, the last having been during the summer of 1909. On each of these voyages the Duke of Orleans has carried with him an excellent scientific staff on board his yacht, the *Belgica*, a vessel already known in Antarctic exploration. Among those who have been with him are Dr. Récamier, who has accompanied the Duke on each of his previous voyages, as well as Captain Adrien de Gerlache, formely leader of the Belgian Antarctic expedition, M. E. Mérite, the artist-naturalist, and Mr. E. Koefoed.

FIG. 1.—The *Belgica* in land ice on August 4, 1905 (Lat. 77° 29′ N., Long. 18° 31′ W.).

The volume opens with a narrative of the voyage and an extract of the ship's journal, by Captain de Gerlache. The *Belgica* left Tromsö on June 3, and, passing northward to the west of Spitsbergen, sighted Prince Charles Foreland in exceptionally clear weather, reaching 80° 20′ N. in this longitude. From this point the Duke attempted to push westward towards Greenland, not to establish "un vain record," but to carry on serious scientific investigations in an unexplored region of the Arctic Ocean. This attempt was repulsed by heavy ice, which drives southward from the polar basin between Spitsbergen and Greenland. The special object was to verify the hypothesis that a ridge separated the Greenland Sea from the North Polar basin, but though unsuccessful in this attempt, the expedition succeeded in crossing from east to west over to the Greenland coast in as high a latitude as 75° 30′ N., a region which has been inaccessible to other expeditions trying it. Along this route a complete set of soundings and serial temperature and salinity observations were made. The coast of Greenland was met on July 27, and the Duke landed on an island, rich with Arctic vegetation, just south of Cape Bismarck, and which he named "Ile Maroussia." At 8 a.m. on July 28 the *Belgica* was four miles north of Koldewey and Payer's cairn, the furthest north point of the German expedition of 1870. At noon the *Belgica's* position was 77° 20′ N., 18° 20′ E., and in the evening a party landed on a previously unknown island, which was named Ile de France, the south-east cape of which, in 78° 38′ N., 17° 36′ W., was named Cape Philippe. Here the French colours were hoisted. Koefoed found nineteen phanerogams, seven mosses, four fungi, and six lichens; hares, ptarmigan, foxes, and lemmings abounded. The remains of Eskimo encampments were also found.

At midnight on July 30 the *Belgica* was in 78° 16′ N., 16° 48′ W., or 167 miles further north than the *Germania* in 1869. From this point the *Belgica* pushed eastward, and thirty miles eastward, after getting shallowing soundings of 245, 120, and 55 fathoms, struck bottom at 32 fathoms, and named this bank the Belgica Bank. Six miles to the south-east of this point the water deepened again to 109 fathoms. de Gerlache suggests that there may be an island in the vicinity, noting that two crows and a walrus were seen. After this the Duke returned by more or less the same route so far as Cape Bismarck, and from there in a more or less southerly direction in, and along, the edge of the Greenland pack, which they lost sight of on August 21 in about 67° 30′ N., 24° E. It is satisfactory to note that at almost the furthest north point reached a well determined position

[1] Duc d'Orléans. "Croisière Oceanographique accomplie a bord de la *Belgica* dans la Mer du Grönland, 1905." Pp. v+568; lxxix plates. (Brussels: Bulens, 1907.) Price 100 francs.

was obtained, viz. 78° 13′ N., 16° 30′ W., and that the coast was mapped approximately to 79° N. All that is mapped is satisfactorily determined except Cape Bourbon and Cape Bergendal, the distances of which were judged, only single angles being taken. A good declination was obtained in 77° 35′ N., the result being 37° N.W.

Full extracts of the journal compiled on board are published. Here we are given the time and position, the weather, the sea, ice observations, stations, and movements of the ship, and the animals met with, in a thoroughly systematic manner. Next come a list of eighty soundings and fifty oceanographical stations, showing good solid work. The soundings vary from 12 to 1846 fathoms. Many hydrographic observations were taken, and plankton and other fishing was carried on.

Meteorology has been well handled by Dr. Dan la Cour, the observations of twenty-two ships having been considered, as well as thirty-eight land stations, though one misses the observations taken by Scottish whalers in the Greenland Sea and Davis Straits. There are ninety-six synoptic charts for July and August, 1905, which are of great interest.

Mr. O. B. Boggild reports on the geology. He has a theory of a submarine moraine existing to the east of Greenland, running parallel with the coast, but this is scarcely supported by the bathymetrical chart (plate lvi.). The geological observations at Cape Saint Jacques (77° 36′ N.), on the Ile de France, are of most interest. Here there are gneisses and schists, and possibly some Devonian rocks probably identical with those that Nathorst found further south. Plate lx. shows deposits from the north of Scotland to north of 80° N. All is blue mud, except the globigerina ooze, which pushes north-east from west of Scotland to within 240 miles of Bear Island, broken only by the volcanic muds of Iceland and the Færöes.

Dr. C. H. Ostenfeld treats the botany in a systematic manner, but beyond the further northern extension of known East Greenland species there is naturally nothing very novel.

Mr. Einar Koefoed and Captain de Gerlache give an account of oceanographical equipment which, with the exception of the excellent Lucas sounding machine, was mostly Danish or Norwegian. There follows a useful journal of the fifty stations, mostly in the Greenland and Spitsbergen seas. This journal gives a summary of the hydrographic and other work done at each station, and lists of planktonic species. Messrs. B. Helland-Hansen and E. Koefoed then proceed to discuss the hydrography of the expedition, and no expense is spared in enhancing this part of the report with a very excellent series of useful, interesting, and beautiful plates and maps for the purpose of demonstrating the distribution of depths, temperature, salinity, currents, &c. Most of the introduction is a summary of the hydrographic work of previous expeditions to the Greenland seas, but Messrs. Koefoed and Helland-Hansen have made no mention of Mr. Leigh Smith's work of 1870, nor of that done on board the *Princesse Alice* during 1898 and 1899, mostly by Mr. J. Y. Buchanan and the reviewer. Leigh Smith was the first to notice the intermediate warm layer in these seas which is specially dealt with by

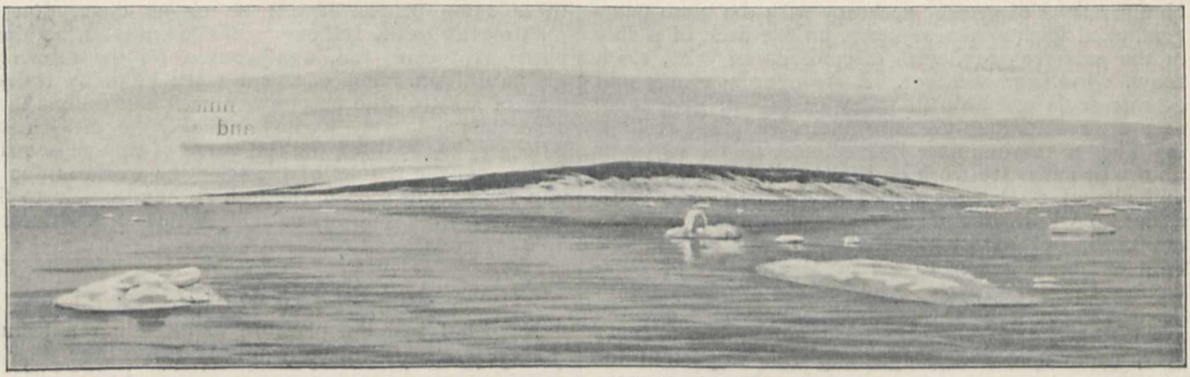


FIG. 2.—Cape Philippe.

FIG. 3.—Duke of Orleans Land, near Cape Amelia

Messrs. Koefoed and Helland-Hansen, yet no mention of this veteran's name or work is made. Buchanan, Nansen, Bruce, and others have also observed this phenomenon. We doubt also if some of these old observations are less exact than those of more recent date. The Buchanan methods give, for instance, observations of great exactitude, and certainly equal to any of the most recent observations of the younger Scandinavian school of oceanographers.

Part ii. deals with instruments and methods; and here useful discussion could be entered upon, as, for instance, on the question as to whether one is able to obtain results of greater accuracy with the more finely graduated Richter thermometer on the deck of a ship in the polar regions, with discomforts of mist, sleet, snow, wind, and weather. A stronger marking and coarser scale certainly in many cases will give more accurate results than the very finely-graduated scale of the Richter thermometer instruments, as the reviewer knows by extensive work on board ship in all weathers and almost all latitudes. The question of a ridge rising to within about 400 fathoms of the surface is discussed, but so far no absolute proof of this has been obtained, owing to the great difficulty of penetrating the polar pack—some of the heaviest ice in the world—between the north of Spitsbergen and the east of Greenland. The Duke of Orleans has, however, come nearer accomplishing this important investigation than anyone else, for he obtained a more complete line of soundings two degrees further north in the middle longitudes of the Greenland Sea than any previous navigator.

The authors divide the Greenland Sea into three areas:—

(1) East—having high temperatures and salinities, being influenced by the Gulf Stream.

(2) Middle—a deeper region with mixed conditions.

(3) West—a shallower region with low temperatures and salinities, being influenced by the polar current.

Plate lxii. gives a chart indicating the stations of the *Belgica* and those of other expeditions in the Greenland seas and regions adjacent; but again we miss the stations of Leigh Smith, 1870, those of Bruce (S.Y. *Blencathra* of Major Andrew Coats), 1898, and those of the Prince of Monaco, 1898–9. Many interesting problems are raised by the temperature, salinity, and current observations made by the Duke of Orleans and his staff, and not least of them is the theory of the Spitsbergen-Greenland ridge already referred to, but it is impossible in this short review to enter fully into all these questions.

The zoology of the voyage, discussed by Prof. C. Hartlaub, Messrs. D. Damas, E. Koefoed, and M. J. G. Grieg, occupies more than a third of the volume. The plankton work is very exhaustively and thoroughly handled by Messrs. Damas and Koefoed. Several dredgings in depths down to 750 fathoms also secured a number of interesting benthoic forms. The numerous inset maps and sectional diagrams and tables are especially useful, bearing as they do on the distribution of plankton.

The plates by Werner and Winter maintain the high reputation this firm has justly won. M. Édouard Mérite's work is reflected throughout the natural history of the expedition, though much of this excellent artist's colour work only appears in the Duke of Orleans's less technical work, "A Travers la Banquise du Spitsberg au Cap Philippe." Dr. Récamier, too, did much to make the voyage a success. There are useful sketches of the new coast between 77° and 79° N., and some most excellent half-tone blocks, many of which show polar ice well; the frontispiece is especially to be commended as "a thing of beauty." One regrets to see that glazed paper is used instead of pure rag paper, which actually produces richer effects and is infinitely more durable.

Altogether the Duke of Orleans is to be most heartily congratulated, not only for having personally conducted all the above work, but even more so for having placed the observations and material gathered during the voyage into competent hands for examination and description, and for having spared no trouble or expense in bringing out a volume which is second to none as a monumental contribution to the oceanography of the Arctic Ocean. Too often polar expeditions are dispatched by the help of men of means, but these same people have little or no conception of making use to the full extent of the material, obtained with great care, toil, and trouble, on the return of the expedition. The excellent work of many trained men of science who accompany such expeditions is in consequence largely wasted. The Duke of Orleans, however, has realised the full value of this subsequent work, and the thanks of the scientific world is due to him for having seen it through so handsomely to the finish.

WILLIAM S. BRUCE.

AËROPLANE STABILITY.

IN 1896 I had the pleasure of attending a lecture on naval architecture given before the British Association in Liverpool by the late Dr. Francis Elgar, F.R.S. I had learnt the theory of the metacentre in my undergraduate days, but it came to me as a great surprise to learn that this theory had only been evolved after many ships had foundered, owing to want of theoretical knowledge of their conditions of stability.

I was interested in aërial navigation at the time, and although I had not got further than throwing gliders, it was evident from their behaviour that a mathematical theory of stability must necessarily be of even greater importance in connection with aërial navigation than with naval architecture, and I wrote in *Science Progress* to the effect that if the future development of artificial flight were not to be a repetition of the chapter of accidents by which naval architects had gained their theoretical knowledge, there would be abundant work for mathematicians in reducing the conditions of stability to pure calculation.

About the year 1903 I noticed that if a glider or other body is moving in a resisting medium, such as air, in a vertical plane with respect to which it is symmetrical, the small oscillations about steady motion in that plane are determined by a biquadratic equation; and Prof. Love directed my attention to the condition of stability given by Routh. Mr. W. E. Williams was a post-graduate student in my department, and with his collaboration we published a paper on "The Longitudinal Stability of Aërial Gliders" (Proc. Royal Soc., lxxiii.), which was intended to direct attention to the general method, and the importance of further investigation, rather than to furnish a complete solution of the problem.

Mr. Williams shortly afterwards obtained a so-called "Research Fellowship"; but "research" in this case was interpreted as meaning practical work done in a physical laboratory away from Bangor, so the award had the effect of preventing the continuation of original work on this important problem. On the other hand, the necessity of providing, with one assistant, classes in all grades of pure and applied mathematics, and of devoting special attention to the requirements of junior students whose knowledge of the "first four books" and of arithmetic had been neglected at school, left no time for me to carry on the work single-handed. It is only since the comparatively recent abolition of these *infra* university courses that I have been able to give any attention to the subject.

Some criticisms having been raised by the late Captain Ferber, mainly referring to the form in which the conditions of stability were stated, I suggested his developing the work as I had not time to do so. His results were published in the *Revue d'Artillerie*, October and November, 1905, and include a discussion of lateral as well as of longitudinal stability.

At the beginning of last year the work of my department was, for some unknown reason, exceptionally light, and I had in Mr. E. H. Harper an assistant well able and willing to collaborate in a much more exhaustive investigation both of longitudinal and lateral stability. About October I received a formal letter of inquiry from the Government Committee, in an envelope which I at first took for an income-tax application, and in reply stated that what I wanted was a small grant to enable me to devote my whole time to this work. I received a reply that the committee "regretted," &c., but that "very great interest was taken" in the work. The main difficulties of the subject have, however, now been practically cleared up, though a long time must elapse before a detailed written account is ready for publication. Had any prizes been offered in England for which such an investigation would be eligible, the delay might have been avoided or shortened.

Reference must be made also to Mr. Lanchester's remarkable investigations, published in his "Aërodonetics," and to the appearance of a German translation of the preceding volume, "Aërodynamics," shortly after its publication in English.

It is here proposed to give a general idea of the peculiarities of aëroplane stability as deduced from my work, and a comparison with Ferber's and Lanchester's methods; though with regard to the latter it is rather difficult for any critic to be sure of not misjudging the author's intended meaning.

It is necessary that the distinction between equilibrium and stability should be kept in mind. An aëroplane is in *equilibrium* when travelling at a uniform rate in a straight line, or, again, when being steered round a horizontal arc of a circle. A badly balanced aëroplane would not be able to travel in a straight line. The mathematics of aëroplane equilibrium is probably very imperfectly understood by many persons interested in aviation, but it is comparatively simple, while the theory of stability is of necessity much more difficult.

It is necessary for stability that if the aëroplane is not in equilibrium and moving uniformly it shall tend towards a condition of equilibrium. At the same time, it may commence to *oscillate*, describing an undulating path, and if the oscillations increase in amplitude the motion will be unstable. It is necessary for stability that an oscillatory motion shall have a positive modulus of decay or coefficient of subsidence, and the calculation of this is an important feature of the investigation. A slight reference to this question of rolling is given by Chatley on p. 99 of "The Problem of Flight," but he seems to have overlooked the fact that this damping may be, and often is, negative in the case of unstable aëroplanes.

At the present time it is certain that aviators rely on their own exertions for controlling machines that are unstable, or at least deficient in stability, and they even allege that, owing to the danger of sudden gusts of wind, automatic stability is of little importance. Moreover, even in the early experiments of Pilcher, it was found that a glider with too V-shaped wings, or with the centre of gravity too low down, is apt to pitch dangerously in the same way that increasing the metacentric height of a ship while increasing its "statical" stability causes it to pitch dangerously. It thus becomes important to consider what is the effect of a sudden change of wind velocity on an aërodrome. If the aërodrome was previously in equilibrium it will cease to be so, but will tend to assume a motion which will bring it into the new state of equilibrium consistent with the altered circumstances, *provided that this new motion is stable.* Thus an aërodrome of which every steady motion is stable within given limitations will constantly tend to right itself if those limitations are not exceeded. Excessive pitching or rolling results from a short period of oscillation combined with a modulus of decay which is either negative (giving instability) or of insufficient magnitude to produce the necessary damping.

The new work depends very largely on the property that for a system of *narrow aëroplanes inclined at small angles to the line of flight* approximate methods may be used, greatly simplifying the algebra, and enabling the various oscillations to be separated and their moduli of decay to be calculated approximately. Of the six equations of motion as applied to the small oscillations of a symmetrical aërodrome, three determine oscillations in the plane of symmetry, and lead to conditions of *symmetric* or *longitudinal* stability. The other three determine asymmetric or skew symmetric oscillations, leading to conditions of *asymmetric* stability. The three equations in each set are mutually interdependent, but independent of the other three, thus accounting for the fact that Lanchester found it impossible to separate "lateral" and "directional" stability. Failing any better terminology, I have provisionally adopted the term "asymmetric" stability.

Of the two, symmetric stability presents by far the simpler problem. For the systems above mentioned there are two symmetric oscillations, one of long and one of short period. The short-period oscillation consists mainly of an oscillatory motion of the centre of gravity perpendicular to the line of flight (*i.e.* a vertical oscillation if the aërodrome is moving horizontally), combined with a rotatory oscillation about the centre of gravity. To a first approximation it produces no fluctuations in the velocity in the line of flight, and is unaffected by head resistance or fluctuations in the propeller thrust, provided the latter passes through the centre of gravity of the aërodrome, as has been assumed in many of our calculations. The condition of stability depends only on the areas and positions of the aëroplanes relative to the centre of gravity, and is independent of the inclinations or angles of attack of the planes, the oscillations remaining finite when the planes are parallel. This condition of stability is generally satisfied in any arrangement which satisfies the other conditions of stability. It must not be overlooked, though it is very unlikely to give trouble. The corresponding *trajectory* or *curve of oscillation* is independent of the velocity, the actual *time rates* of oscillation and decay being proportional to the velocity.

In the slow oscillations the variations of velocity in the line of flight are a predominating feature. The trajectory is wave-like, the crests of the waves being more pointed than the troughs, and the descending parts steeper than the ascending ones. This is evidently the type of oscillation studied by Mr. Lanchester. One condition of stability is that the front plane (or planes) must be inclined at a greater angle than the rear ones. The second condition depends on the type of machine.

The terms "monoplane" and "biplane," as usually defined, refer to the question of whether a machine has not or has superposed planes. According, however, to a property which I call the *principle of independence of height,* this distinction does not affect stability to any appreciable extent. The important point is whether the weight is sustained partly by the front and partly by the rear planes, as in certain Voisin machines, or is wholly supported by the front planes, the rear ones acting merely as a tail in the neutral position. For a monoplane with neutral tail the condition of stability takes the form given by Lanchester, when the necessary substitutions have been made by making use of the condition of equilibrium. The reason why Lanchester's method leads to a correct result is to be sought in considerations of the peculiar nature of the oscillations, and in especial in the relative smallness of their modulus of decay. For a machine of the Voisin type, with sustaining surfaces arranged tandem, the condition of stability is nearly as simple, and certain modifications are sufficient to cover the case when the propeller thrust does not pass through the centre of gravity provided that this thrust is constant.

A very convenient plan in such cases is to suppose the actual machine replaced by an *equivalent monoplane,* with neutral tail, although if the inclinations of the planes be varied for vertical steering the equivalent monoplane will be changed.

The most remarkable result, however—and Mr. Harper was the first to point this out to me—is the *important effect on stability of the direction of motion in the vertical plane.* Longitudinal stability falls off rapidly when the aëroplane begins to rise, even if other things are constant. A monoplane would, under theoretical conditions, become unstable when ascending at an angle to the horizon of *less* than twice the angle of attack (or inclination of the main plane to the line of flight).

The effect of head resistance is to increase the stability, and a further increase occurs if the thrust of the propeller, instead of being constant, decreases when the velocity increases. By the use of three planes instead of two, an additional increase of stability can be obtained. On the other hand, if the aëroplane be gliding downwards the longitudinal stability is greater than in horizontal flight.

I think the above conclusions indicate a source of danger which may possibly have led to mishaps when aëroplanes have risen too rapidly in the air.

Captain Ferber's investigations, on the other hand, refer mainly to the stability of a single aëroplane as dependent on fluctuations in the position of the centre of pressure consequent on variations of the angle of attack. He assumes Joessels's formula, introducing two arbitrary constants in place of the numerical coefficients. The difficulty I have several times pointed out is that, if a plane is turning over, its rotational motion may affect the position of the centre of pressure, as well as possibly the resultant thrust, and no experimental information is apparently available on this point. For this reason the use of narrow aëroplanes is to be recommended, stability being secured by a tail or by two planes placed one behind the other. Moreover, the theory of narrow aëroplanes gliding at small angles affords the simplest introduction to a general study of aëroplane stability, just as geometrical optics in which aberration is neglected affords an introduction to a general study of lens construction. It is to be remembered that both the symmetrical and asymmetrical oscillations are determined by equations of the fourth degree, each in the form of a determinant of the third order containing the dynamical constants and resistance coefficients, and when this determinant has been expanded, *four* conditions of stability have to be satisfied, one being that Routh's discriminant $BCD - AD^2 - EB^2$ shall be positive. Fortunately, for purposes of approximation, $CD - EB$ may be substituted for the last in many of the systems occurring in aviation. It will thus be seen that stability is a very complicated problem, and that approximate methods are essential.

Asymmetric stability is far more difficult of investigation than symmetric. It is necessary to take account of the separate effects of straight or horizontal aëroplanes, vertical fins, and bent-up or V-shaped planes. The late Captain Ferber's solution is based on the substitution for the actual planes of their projections on three coordinate planes (p. 46 of his paper). Unfortunately, even assuming the sine law of resistance, this substitution does not seem to give even the correct first approximation which is all the author claims. In particular, if the aërodrome is rotated about any axis in its plane of symmetry, couples are set up on the main aëroplane which have an important effect on the stability, but are apparently not included in his scheme. The final result is a biquadratic with one root equal to zero, and Captain Ferber regards an aëroplane as stable when it describes a helix; whereas such an arrangement should really be regarded as lacking in stability. The couples in question are taken account of by Lanchester, who uses what he calls "aërodynamic and aërodromic radii" to represent their effects. For a narrow aëroplane gliding at a small angle, the effect depends on the moment of inertia of the area of the plane about the vertical plane of symmetry. A horizontal tail of negligible lateral dimensions does not affect the asymmetric stability.

To secure stability, recourse must be had to vertical fins, or to bent-up aëroplanes or aërofoils. The effect of vertical fins (neglecting "wash") depends on their areas, and the first and second moments of these about the axes, and in studying them it is necessary to have recourse to the "principle of parallel axes." The sections in "Lanchester" on "fin resolution" practically embody this principle, but are a little difficult to follow; they suggest the path taken by an explorer who had not a compass to guide him to the mathematically direct road in the form of the principle in question. His conditions of stability seem reasonable deductions from the hypotheses he makes, but the conclusions must not be regarded as final. Both the necessary and the sufficient conditions of stability are really far more complicated, and it is highly improbable that the problem could have been carried much further without the elaborate use of analysis which I have found necessary, and the assistance of an independent calculator, which Mr. Harper has kindly provided. The only way of proceeding was to calculate the coefficients in the biquadratic for particular arrangements of fins and planes, starting with the simpler ones, and passing to more complicated ones *when one has become thoroughly familiar with the different terms and their meanings.*

For an aëroplane with one vertical fin only, the conditions of asymmetric stability require that the centre of pressure of the fin should be slightly in front of the centre of gravity of the machine, while at the same time it should be at a height above the centre of gravity large compared with its distance in front. Two of the conditions of stability are difficult to reconcile with the conditions of equilibrium, the difficulty increasing as the velocity increases and the angle of attack diminishes; moreover, they are inconsistent unless a certain relation holds between the radii of gyration of the machine and of the main supporting surface. It is doubtful whether this condition would be consistent with practical requirements.

The failure of practical aviators to obtain automatic stability may be due in no small measure to the number of conditions that have to be satisfied. A vertical fin in front might satisfy one condition of stability, and introduce instability through another condition, while a similar fin at the back might satisfy the second condition and introduce instability through the first. In either case the impression produced would be that the device secured automatic stability, but that such stability was a hindrance rather than a help, the correct interpretation being that the conditions of stability had not been sufficiently investigated. By abolishing the fins the aviator would obtain a machine with *defective stability, i.e.* with one or more roots of the biquadratic vanishing, and would find it easier to maintain his balance by artificial control than in the previous unstable arrangement.

Of arrangements with two fins, the cases have been considered where both fins are at the level of the centre of gravity, where one is above, and where both are above. The conditions of stability assume various forms, but there is one arrangement which appears to possess an exceptionally wide range of stability, and I have made provisional application for a patent in this connection.

A machine such as the Voisin type, with two planes of considerable span at different angles of attack, is more stable than one with a single sustaining system, and the difference is equivalent to a variation in the arrangement of the fins which is easily calculated.

The asymmetric oscillations of an aërodrome do not separate into two kinds, of long and short period, like the symmetric ones. As a general rule the biquadratic has one root determined approximately by the first two terms representing a quick subsidence, one root determined by the last two representing a slow subsidence, and a pair of roots determined by the middle terms representing a damped oscillation.

The inclination of the flight-path to the horizon has a considerable influence on the asymmetric stability. In several instances we found that instability occurs when an aërodrome is descending at an angle to the horizon the tangent of which is double that of the angle of attack of the main planes. Other arrangements become unstable when rising at more than a certain angle; in the best arrangement referred to above the stability is practically independent of the inclination. As the symmetric and asymmetric oscillations of an aëroplane are independent, it is important that it should preserve its asymmetric stability even when it is not in longitudinal equilibrium. The dependence of stability on inclination affords a very simple and likely explanation of certain "vagaries" described on pp. 342, 343 of Lanchester's "Aërodonetics"; account would, however, have to be taken of accelerations of the centre of mass in an exact comparison of theory with observation.

Bent-up or V-shaped wings lead to much more difficult analysis, and it appears that their effect is not exactly equivalent to any combination of vertical fins except in certain cases. A pair of "stabilisers" or small planes, which may be fixed at the extremities of the main aëroplanes at an angle of, say 45°, is equivalent to a single raised vertical fin if the planes of the stabilisers are parallel to the line of flight.

Mr. Harper has worked out the asymmetric stability of the Antoinette type with a single pair of bent-up supporting surfaces. The conditions of stability are satisfiable by furnishing the machine with a tail of suitable length, or by raising the dihedral angle of the V-shaped wings above the centre of gravity.

I should like to direct attention to the importance of eliminating the personal element in experimental tests of aëroplane stability, by the use of models. The possibility of long-distance flights by skilled aviators having been demonstrated, there is not so much point in repeating these verifications as in extending our knowledge in other directions, and finding how far the element of skill can be dispensed with by effecting improvements in aëroplane design.

The stability of dirigibles opens up another field of study, on which we hope to do something during the coming year.

Owing to the attention now given to aëroplane construction, it appeared desirable to give, in the present article, an advance account of investigations which may not be ready for publication *in extenso* for some time to come.

G. H. BRYAN.

Added January 27, 1910.—The *Aëronautical Journal* for January, now to hand, includes a short abstract, illustrated by badly executed diagrams, and containing numerous uncorrected printers' errors, in which the symmetric stability of a single-surfaced aërodrome without tail is made to depend on a cubic instead of a biquadratic equation. This result is obtained by the very doubtful method of "assuming V to be constant for a short period," that is, neglecting fluctuations in horizontal velocity. Owing to this assumption the conclusions reached may perhaps represent the conditions that the machine may be stable with reference to the shorter oscillations, but not with respect to the longer ones, and the inference that a machine can be much more stable at moderate velocities than is generally supposed must not be regarded as conclusive.

THE WORK OF THE WOBURN FRUIT FARM.[1]

AMONG the profusion of agricultural and horticultural reports, many of which can at best be said only to possess a very ephemeral interest, it is pleasant to come across something of permanent and abiding value, work carefully executed and followed to its logical conclusion.

Such must be the feeling of every discerning reader as he studies the report by the Duke of Bedford and Mr. Spencer Pickering on the chemical relationships of the copper fungicides. The problem is one of very great economic importance. Modern conditions of fruit-growing tend to foster and distribute from country to country the fungi parasitic on fruit trees. On the other hand, the grower is more and more anxious to keep them down; not only do they adversely affect his yield, but they often spoil the looks of his fruit, a very serious matter in modern markets.

The most popular fungicides are the copper compounds, more particularly Bordeaux mixture, a basic salt prepared by adding lime to a solution of copper sulphate. This mixture has been used by fruit and potato growers for a number of years with great success, and has formed the subject of a vast number of papers. Unfortunately few of them are of much value, since it only rarely happens that a man is found to combine an interest in horticultural problems with exact habits of thought. Until recently nothing was known of the composition of Bordeaux mixture, not even the proportions in which the constituents should be mixed to give the best results. Certain American investigators recommended 4 lb. of copper sulphate in fifty gallons of water, and some of the English writers, borrowing not too intelligently in this as in other matters, recommended the same strength, oblivious of the fact that the American gallon is little more than four-fifths of the English

[1] Eleventh Report of the Woburn Experimental Fruit Farm, by the Duke of Bedford, K.G., F.R.S., and Spencer U. Pickering, F.R.S. (The Amalgamated Press, Ltd., 1910.)

gallon. There are several other recipes, but nothing enabling one to decide which is the best. The mode of action is even more obscure; indeed, the whole subject was in a state of confusion until Mr. Pickering took it in hand and began to evolve something like order.

The reaction between copper sulphate and lime is shown to yield four basic sulphates:—(*a*) $4CuO,SO_3$; (*b*) $5CuO,SO_3$; (*c*) $10CuO,SO_3$; (*d*) $10CuO,SO_3,CaO$; and two other compounds (*e*) $CuO,2CaO$ (existence doubtful); (*f*) $CuO,3CaO$. The conditions of the formation of each of these basic sulphates were investigated and a series of the corresponding Bordeaux mixtures prepared.

The properties of the sulphates were studied, and in particular their decomposition under the influence of water and carbonic acid in presence of calcium sulphate or of organic matter, these being the conditions obtaining on the leaf surface. The next problem was to ascertain the function of Bordeaux mixture and so to settle which was the most useful of the possible basic sulphates. These salts are, of course, insoluble and have to be converted into a soluble substance before they can exert a fungicidal action. No evidence could be obtained that the plant leaf or the spore excreted anything that would dissolve an insoluble substance, but it was shown that the carbonic acid of the air decomposed these basic sulphates in accordance with the following reactions:—

(*a*) $10CuO,2\cdot5SO_3 + 3\cdot75CO_2 = 3\cdot75(CuO)_2,CO_2 + 2\cdot5CuSO_4$.
(*b*) $10CuO,2SO_3 + 4CO_2 = 4(CuO)_2,CO_2 + 2CuSO_4$.
(*c*) $10CuO,SO_3 + 4\cdot5CaO = 4\cdot5(CuO)_2,CO_2 + CuSO_4$.
(*a*) $10CuO,SO_3,3CaO + 7\cdot5CO_2 = 4\cdot5(CuO)_2,CO_2 + 3CaCO_3 + CuSO_4$.

The copper sulphate thus liberated constitutes the active part of the mixture. It acts in two ways. It directly poisons the fungus cell developing from the spore. Some of it gets into the leaf, displacing a certain amount of iron and entering into a remarkable combination not yet investigated, which seems so long as it persists to afford the leaf immunity against fungal attacks. Further studies of this remarkable body will be awaited with interest; it will be remembered that Church isolated a pigment *turacin* containing copper from certain genera of the family Musophagidæ, but no such pigment is known in the vegetable kingdom up to the present. But to return: the object of the fungicide is to furnish a steady supply of copper sulphate, and therefore the compound (*a*) is the most efficient of the series. In the case of (*d*), the ordinary Bordeaux mixture, a secondary reaction sets in between the calcium carbonate and the copper sulphate which further reduces its efficiency. (*a*) is, however, physically less suitable than (*c*). The whole leaf surface of the tree has to be covered with the mixture, and consequently the more bulky the mixture the better; since (*c*) occupies more than four times the volume of (*a*) it makes the most economical fungicide in practice. From the fruit-grower's point of view this compound has the further advantage that it can be made on the commercial scale and sent out as a paste ready for use. The paste has been extensively tried in orchards, with results that have completely confirmed the laboratory experiments. Several interesting side-issues were followed up. Some of the compounds in the ordinary Bordeaux mixture and in the so-called soda Bordeaux, obtained by mixing copper sulphate and sodium carbonate, contain copper in the electronegative condition, *i.e.* in the acid radical, and were called cupricarbonates; they appear to have no fungicidal action, they combine with cellulose, and slowly decompose to form cuprous oxide.

The report will be found one of the most interesting that has issued from Woburn. E. J. R.

UNDERGROUND TOPOGRAPHY IN IRELAND.

THE exploration of caves has become an athletic pursuit for certain enthusiastic specialists, perhaps as a complement to mountain-climbing. The results, however, have distinct scientific value, when careful plans of the caves are made, and underground waterways are traced. Attention has been directed in these pages to the economic bearing of "spelæology" in the Juras, and the work of the geographer is obviously incomplete, if his streams terminate, as so often happens, in swallow-holes in a limestone area, while others appear freshly on the surface, but may prove to be old friends returning to the upper world. Cave-research is arduous and often dangerous, and the wonder is that such accurate observations are provided for us by men who have to work under cramped conditions, and sometimes liberally immersed in water.

The Royal Irish Academy (Proceedings, vol. xxvii., section B, 1909) has recently issued two geographical memoirs on Irish caves. The first (pp. 183–192, price 6*d.*) is by Mr. Harold Brodrick, on "The Marble Arch Caves, County Fermanagh: Main Stream Series." The principal cave was explored and described by M. Martel some twelve years ago, with the assistance of the Irish naturalist, Dr. H. Lyster Jameson. Mr. Brodrick, with Dr. C. A. Hill, Mr. R. Lloyd Praeger, of Dublin, and other workers, was able to devote a longer time to the exploration of the district. The training and experience gained by most of the party in Yorkshire enabled them to add many new points to the topography of the area. As Mr. Brodrick remarks, the Marble Arch cave will "probably never become a show-cave, as the climb from the foot of the Great Boulder Chamber to the end of the Pool Chamber Passage is not one to be rashly undertaken." The by-paths of the recent exploration led the adventurers into several difficult places, not to speak of waters, where few will care to follow them. A large-scale map is provided, on which, however, the names used in the text are not always to be found.

The second paper (pp. 235–68, with four plates, price 1*s.* 6*d.*), on "The Mitchelstown Caves, County Tipperary," has a wider general interest. The authors are Messrs. C. A. Hill, H. Brodrick, and A. Rule; but Mr. R. Lloyd Praeger took part in the exploration. The New Cave, between Mitchelstown and Cahir, is probably the best-known cave in Ireland; but the plan now given of it seems to be far more accurate than that published by M. Martel, and includes several passages and chambers previously unrecorded. The work may not have been so exciting as that among the unfathomed waterways of Fermanagh, but one and a half miles of cave and passage have been mapped out. A curious point is that the names "Demon Cave" and "Victoria Cave" were found chalked up in some of the unrecorded portions, and these have been adopted in the plan. The names in this plan, by the bye, require one or two corrections to bring them into agreement with the text. The account of the New Cave might have been rendered even more complete by a reference to Prof. Carpenter's paper on its fauna in the *Irish Naturalist* for 1895.

Still more interesting is the description of the smaller Old Cave, which had apparently not been visited by tourists since 1833. The plan now given, covering 479 yards of cave and passage, is the first that has been made.

The clay of the cave-floors, which, as all visitors know, renders them unpleasantly slippery, is described on p. 267 as derived by inwashing from the Old Red Sandstone; but the quartz crystals noted in it, which are so common in the Carboniferous Limestone, and its general character as a *terra rossa,* make it immensely more probable that it is a residue from solution of the limestone.

The paper is well illustrated, and one photograph shows an "anemolite," or stalactite the growing tip of which has been bent sideways by the action of air-currents.

Mr. Brodrick has also published a general account of the explorations in Fermanagh in the Yorkshire Ramblers' Club Journal. G. A. J. C.

NOTES.

THE following fifteen candidates have been selected by the council of the Royal Society to be recommended for election into the society:—Mr. J. Barcroft, Prof. G. C. Bourne, Prof. A. P. Coleman, Dr. F. A. Dixey, Dr. L. N. G. Filon, Mr. A. Fowler, Dr. A. E. Garrod, Mr. G. H. Hardy, Dr. J. A. Harker, Prof. J. T. Hewitt, Prof. B. Hopkinson, Dr. A. Lapworth, Lieut.-Colonel Sir W. B. Leishman, Mr. H. G. Plimmer, and Mr. F. Soddy.

INVITATIONS have been issued to meet the general board of the National Physical Laboratory at the laboratory on Friday, March 18, when the various departments will be open for inspection, and apparatus will be on view.

SIR VICTOR HORSLEY, F.R.S., has been elected a foreign associate of the French Academy of Medicine.

DR. W. F. HUME has been appointed director of the Geological Survey of Egypt.

MR. ANDREW CARNEGIE has offered (the *Times* states) to give a prize of 5000*l.* to the first student of the Carnegie School of Technology at Pittsburg who constructs an aëroplane satisfying certain conditions.

THE Friday evening discourse at the Royal Institution on March 11 will be delivered by Dr. H. Brereton Baker on "Ionisation of Gases and Chemical Change," and on March 18 by Sir J. J. Thomson on "The Dynamics of a Golf Ball."

THE death is reported, at the early age of thirty-three, of Mr. J. F. Ferry, for many years an ornithologist in connection with the Field Museum, Chicago. In collecting for that museum he made expeditions among the islands of the Caribbean Sea and along the coast of the Gulf of Mexico. He also carried out investigations in Arizona for the U.S. Biological Survey, and in the mountains of California for the Smithsonian Institution.

THE following appointments have been made recently by the governing body of the Lister Institute of Preventive Medicine:—Mr. H. R. Dean and Dr. G. H. Macalister, assistant bacteriologists to the institute; Dr. H. McLean, senior assistant in the bio-chemical department; Mr. Ashley Cooper, Jenner memorial research student; Mr. Roland V. Norris, Grocers' Company research student; Mr. S. G. Paine, research student in the chemical department.

THE annual conversazione of the Selborne Society was held in the theatre and halls of the Civil Service Commission on Friday, February 18. Sir John Cockburn, K.C.M.G., gave an address on the objects of the society and the aims of its members, while Mr. E. J. Bedford lectured on "Gilbert White and his Associations with Selborne." Among the interesting exhibits was a working model of a pole-lathe still in use for turning bowls in Berkshire, which was made and exhibited by Mr. William Lawrence. The number of microscopes shown amounted to one hundred, and the evening was probably the most successful yet arranged.

THE Geologists' Association is making arrangements for an Easter excursion to north Devon. It is intended that the excursion shall last from March 24 to March 30, and be under the directorship of Messrs. J. G. Hamling and Inkermann Rogers. The official party is to leave Paddington by the 1 p.m. train on March 24 for Barnstaple. On successive days the Upper Culm Measures, the Upper Devonian, the Lower Culm, and the Lower Devonian are to be studied in different districts. Full particulars as to the excursion can be obtained from Mr. Mark Wilks, 47 Upper Clapton Road, London, N.E.

THE Blue Hill Meteorological Observatory, situated near Boston, U.S.A., has just completed an existence of a quarter of a century. Founded and maintained by Prof. A. Lawrence Rotch, detailed measurements of cloud heights and velocities were early conducted, and in 1894 the first meteorological records in the world were obtained with kites at this station. These were extended ten years later with sounding balloons to great heights above the centre of the American continent, and, through the co-operation of M. Teisserenc de Bort, over the Atlantic Ocean (NATURE, vol. lxxiii., pp. 54–6, 449–50; vol. lxxx., pp. 219–21). These observations in the free air, like those made elsewhere in the interest of aërology for the International Commission for Scientific Aëronautics, have now become useful to aëronauts and aviators.

PROF. W. KRAUSE, whose death was recently announced from Berlin, at the age of seventy-six, was one of the better known of modern German anatomists. He was a son of the famous Dr. Carl Krause, professor of anatomy in the University of Hanover, who published a remarkable text-book of anatomy—"Handbuch der menschlichen Anatomie"—in 1833. The preparation of the third edition of this work, from 1876 to 1880, constitutes one of the most important contributions made to anatomy by the late Prof. W. Krause. His researches on the terminal organs (end-plates) of motor nerves gained him an early and wide reputation among histologists. Originally professor of anatomy in the University of Göttingen, he went, late in life, to Berlin, where he occupied the position of head of the anatomical laboratories of the University, under the directorship of the veteran anatomist, Prof. Waldeyer.

FEBRUARY was a stormy and unsettled month over the whole of the British Islands, and the total rainfall was large. At Greenwich the mean temperature for the month was 42·1°, which is 2·3° warmer than the average of the previous sixty years; the mean of the day readings was 48°, and the mean of the night readings was 36°. Frost occurred in the screen on seven nights, but on the grass in the open on fifteen nights. The aggregate rainfall at Greenwich was 2·72 inches, which is 1·23 inches more than the average; rain fell every day with three exceptions. February was wetter than any corresponding month during the last ten years. The sun was shining for seventy hours, which is thirteen hours in excess of the average. Cyclonic systems traversed our islands with great frequency during the month, the central areas following a track well to the northward, so that westerly winds greatly predominated. The Meteorological Office, alluding to the violent gale which occurred on Sunday, February 20, mentions that the squalls reached "storm" force in many parts of the country, and "hurricane" force at Southport, Scilly, and Pendennis Castle. The maximum velocity of the wind at Southport was at the rate of more than eighty-five miles an hour, using the new factor for the wind velocity as determined by the Meteorological Office.

The Royal Meteorological Society held its first meeting out of London on Wednesday, February 23, in the physical laboratory of the Manchester University. Dr. Hopkinson, the Vice-Chancellor, expressed the gratification the University felt at receiving the fellows of the society. He said that the history of the University showed that they were not merely in expression, but in act, interested in this branch of scientific work, as much had been accomplished in meteorology by the work initiated and supported by Dr. Schuster. Dr. A. Schuster also welcomed the society, and said that, although meteorology in itself might be regarded by some as a small part of physical science, yet it was intimately connected with a number of other subjects, especially with one large subject which he thought had received far too little attention in the universities, namely, the whole physics of the globe.

We learn from *Science* that the board of managers of the National Geographic Society has adopted the following resolutions:—"The National Geographic Society believes that it is of importance to science that tidal, magnetic, and meteorological observations shall be obtained at or in the vicinity of Coats Land during the same period that the British expedition under Captain R. F. Scott, R.N., is making similar observations on the other side of the Antarctic area, 1800 miles distant, and at the same time that this recently discovered land shall be explored. That the society is ready to accept Mr. Peary's proposition that it shall undertake jointly with the Peary Arctic Club an expedition to the Antarctic regions as outlined above, provided that the board of managers, after consultation with the members of the society, finds that the project will receive sufficient financial assistance to warrant the undertaking."

Dr. Charcot gives in the Paris edition of the *New York Herald* an account of the scientific work accomplished by his recent Antarctic expedition. He says that during the whole duration of the expedition, both while in winter quarters and during the two voyages, the scientific work was carried out unceasingly. During the whole of the voyages oceanographic soundings were taken and dredgings made. At the same time hydrographic and meteorological observations were made, and natural-history studies effected. These were also carried out while in winter quarters. Very complete maps were made of the regions seen from the coasts, and astronomical observations and studies in terrestrial gravitation were carried out at numerous stations. The seismograph was at work in the winter quarters and on Deception Island. Observations in meteorology, atmospheric electricity, and physical oceanography, including numerous soundings, were carried on almost continually while the expedition was in winter quarters.

The thirty-second annual general meeting of the Institute of Chemistry was held on Tuesday, March 1, Dr. George Beilby, F.R.S., president, in the chair. In moving the adoption of the report of the council, Mr. David Howard alluded especially to the new requirement in the final examination of a useful knowledge of French and German. He believed that this addition would prove of great benefit to chemists, and he knew that it could be left to the examiners to apply the test of this knowledge humanely. They did not want school, commercial, or legal French and German, but a useful knowledge sufficient to enable them to consult technical literature in those languages. Dr. Beilby then delivered his address. He remarked that the institute had undoubtedly influenced the teaching of the universities and colleges, and had endeavoured to encourage the production of men who could not only talk about chemistry, but were able to apply their knowledge usefully. In moving a vote of thanks for the address, Sir William Ramsay said he was inclined to think that the tendency was to trust too much to the results of examinations. He was of opinion that the aim of the examiners should be to ascertain if the candidates could converse freely and easily on their subject and put it into practice.

A prize of 3000 lire (about 120*l.*) is to be awarded by the section of physical sciences of the Royal Academy of Bologna. The competition is an international one, and the prize is due to a generous donation to the section by a corresponding member, Prof. Elia de Cyon. The object of the competition is to further researches and studies in the subjects which he took up with much success. The subjects of the works submitted for the prize are to have reference particularly to:—(1) the functions of the heart, and especially of the nervous, cardiac, and vaso-motor systems; (2) the functions of the labyrinth of the ear; (3) the functions of the thyroid gland, the hypophysis, and the pineal gland. The works submitted must be of recent date, in the case of the present (the first) competition not prior to March 1, 1909. Memoirs may be written in Latin, Italian, French, German, or English. Competitors may be called upon to repeat their experiments in the presence of the three members of the adjudicating committee. The prize will not be divided, and may not be conferred more than once upon the same person. The section of physical sciences reserves the right to publish the successful paper in its Transactions. No member of the section is eligible for the competition. Further particulars may be obtained from Il Segretario, Classe di Scienze Fisiche, R. Accademia delle Scienze, Bologna.

In our issue for December 23 last we recorded Mr. Otto Beit's munificent gift of 215,000*l.* for the foundation and endowment of medical research scholarships. The trustees of the fund met on February 23, and awarded the first set of the fellowships. Seventy applications were received—fifty-eight from England, three from Scotland, one from Ireland, one from Wales, and seven from abroad. The following fellows were elected, and were authorised to proceed with the researches mentioned after their names:—Mr. G. H. Drew, the zoological distribution of cancer and a systematic study of an experimental character on the mode of origin of neoplasms (tumours); Dr. F. W. Edridge-Green, various problems connected with vision and colour-vision, especially in relation to the correct reading of signals on land and sea; Mr. E. Hindle, the morphology and treatment of protozoic blood parasites, especially *Spirochaeta duttoni* and trypanosomiasis (sleeping sickness); Dr. T. Lewis, the mechanism of irregularities of the heart; Dr. G. C. McKay Mathison, (*a*) the nervous control of respiration, and (*b*) the effect on respiration of changes in the chemical composition of the blood; (*c*) the mechanism of biliary secretion and its general effect in digestive processes; Dr. Otto May, clinical and experimental research on the lesions of peripheral nerves; Mr. E. Mellanby, the significance of the large excretion of creatin in cancer of the liver and its diminished excretion in cirrhosis of the liver, &c.; Dr. F. P. F. Ransom, the mode of action of caffeine, theobromine, and allied substances on the muscular and nervous systems; Dr. S. Russ, the association of radio-activity with cancer; Dr. Ida Smedley, the processes involved in the formation of fat in the organism. The next election of fellows will be held about December 15 next. All inquiries should be addressed to the honorary secretary, Beit Memorial Fellowships for Medical Research, 35 Clarges Street, Piccadilly, London, W.

THE death is announced of M. Philippe Thomas, the eminent and enthusiastic geologist who did important pioneer work in Tunis and Algeria. Born at Duerne (Rhône) in 1843, he entered the veterinary school at Alfort in 1860, and became a prominent member of the French army veterinary service, from which he retired about nine years ago. From his earliest youth he was deeply interested in geology, and when his official appointment took him to Algeria he devoted his scanty leisure to the study and collection of the rocks and fossils of that country, and was especially eager in the search for evidence of primitive man. During twenty years he published a series of notes and papers on subjects ranging from man and Tertiary vertebrates to the stratigraphy of the region. In 1884 he was chosen by the Minister of Public Instruction to join the well-known scientific mission to Tunis as one of the geologists, and there he had ample scope for the exercise of his abilities. He discovered the immense deposits of phosphatic chalk, which have subsequently proved of so great economic importance to Tunis. He amassed material for an exhaustive description of the geology of the country, and his later years were occupied with its preparation for publication. Unfortunately, only two parts of this work appeared, and the third part, dealing especially with the phosphatic deposits, remained unfinished at the time of the author's death.

AN appreciative account of the scientific work of Mr. Edward Saunders, F.R.S., who died, we regret to learn, on February 6, in his sixty-second year, appears in the March number of the *Entomologist's Monthly Magazine*, of which he was an editor. From this notice we extract the following particulars of Mr. Saunders's career:—Edward Saunders devoted himself first to the Coleoptera, but acquired also considerable familiarity with entomology in general, and with several other of the "systematic" sciences, such as botany and conchology. At the age of sixteen he published a paper in the first volume of the *Entomologist's Monthly Magazine* on Coleoptera at Lowestoft, and was afterwards for some years mainly occupied in studying the Buprestidæ of the world. A succession of notes, descriptions, revisions of particular collections, groups, &c., bearing on this subject were communicated by him to the Transactions of the Entomological Society from 1866 to 1869; in 1870 he published a "Catalogue of the Species contained in the Genus Buprestis, Linn.," and in 1871 his "Catalogus Buprestidarum Synonymicus et Systematicus," a work the importance of which was immediately recognised. From 1872 to 1874 he continued his work on this group, describing several new genera and more than a hundred new species, and at the same time began to issue a long series of notes on British Hemiptera, which were followed in 1875–6 by a synopsis, in three parts, of the British Hemiptera-Heteroptera, and this again by a large illustrated volume, his well-known "Hemiptera-Heteroptera of the British Isles," which was published in 1892. Concurrently with this important mass of work on two distinct orders of insects he began to attack a third group, the Aculeate Hymenoptera, to which he gradually transferred his chief attention. For the rest of his life the Aculeates (especially the British species) became his favourite study, and he ultimately became, not merely the foremost, but, it may almost be said, the final authority upon the latter. His grand work "The Hymenoptera-Aculeata of the British Isles" (1896) is one of the few without which no serious hymenopterist thinks his working library complete. Saunders became a Fellow of the Entomological Society in 1865, served as treasurer from 1880 to 1890, and was a vice-president in no fewer than five sessions, viz. in 1874, 1899, 1901, 1906, and 1907. Though he never actually held the presidency, it is scarcely a secret that he would more than once have been elected to it unanimously if he could have been persuaded to accept a post the duties of which he felt unequal (physically) to discharge so completely as he would have wished. He entered the Linnean Society in 1869, and about that time contributed at least three papers to its journal. Long after, in 1890, he published in the same journal an exceedingly careful and interesting paper on the tongues, &c., of bees, with beautiful illustrations, drawn by his brother, Mr. G. S. Saunders, from microscopic preparations made by Mr. Enock. His election in 1902 to the honour of fellowship in the Royal Society was not only highly gratifying to himself and his personal friends, but to all who saw in it a recognition of systematic entomology, treated as Saunders treated it as no mere idle dilettantism, but a genuine branch of science.

ONE of the features of the fauna of continental Africa is the absence of flying-foxes of the typical genus Pteropus, this absence extending also to the island of Zanzibar. On the other hand, representatives of these bats occur in Madagascar and the Mascarene, Comoro, and Seychelles group. Recently, specimens of a new species of flying-fox have been obtained from the island of Pemba, which lies to the north of Zanzibar at a distance of only about 37½ miles from the mainland. That the genus should be found so close to the African continent, and yet should never have reached the same, is very remarkable, especially when the long interval between the Comoros and Seychelles, on the one hand, and the Andamans and Ceylon, on the other, is borne in mind. The Pemba species, which is described by Dr. P. Matschie in the *Sitzungsberichte Ges. naturfor. Freunde*, Berlin, 1909, p. 482, belongs to the short-nosed group of the genus distinguished as Spectrum, and has been named *Pteropus voeltzkowi*.

IN vol. xxxii., part i., of Notes from the Leyden Museum, Dr. F. A. Jentink describes a new bat from Java, and at the same time proposes the name Chrysopteron for the Celebesian *Cerivoula weberi* and the new species, which are regarded as constituting a genus by themselves. The typical plantain-bats of the genus Cerivoula (Kerivoula) are characterised by the normal form of the upper canines and the tricuspid first pair of lower incisors; a second genus, Phoniscus, as represented by *P. atrox* of Sumatra, differs by the elongation and compression of the shaft of the upper canines and the quadricuspid first lower incisors, while the new genus is characterised by the presence of four cusps to both first and second lower incisors. It may be pointed out that Chrysopteron, which includes the Celebesian *C. weberi* and the Javan *C. bartelsi*, is practically identical with the much earlier name Chrysoptera.

CONSIDERABLE interest attaches to two papers, by Mr. Knud Andersen, in the January number of the *Annals and Magazine of Natural History* on the African fruit-bats of the Epomophorus group. Hitherto, with the exception of *Hypsignathus monstrosus*, all these bats have been very generally included in the single genus Epomophorus. The author shows, however, that the Angolan *E. anchietae*, on account of possessing $\frac{4}{5}$ pairs of cheek-teeth (in place of the usual $\frac{5}{5}$), the great width of the palate, and other cranial characters, is entitled to rank as a genus by itself, for which the name Plerotes is proposed, this genus being intermediate between Rousettus (cheek-teeth $\frac{5}{6}$) and Epomophorus. Next to Plerotes comes the genus Epomops, as represented by *E. franqueti* and *E. comptus*, in which the muzzle and palate are also wide, although somewhat less so than in the Angolan genus, the hind portion of the palate retaining the flattened form characteristic of Rousettus and its allies. In Epomophorus, on the other hand, the palate is narrow and deeply hollowed out behind, thereby differing from the same region in all other members of the fruit-eating group. Lastly, we have the genus Micropteropus, characterised by the extreme shortness of the skull, which approximates in this respect to that of Cynopterus.

A SHORT paper on the gametophytes of the orchid, *Calopogon pulchellus*, is contributed by Miss L. Pace to the *Botanical Gazette* (August, 1909), which adds to the gradually accumulating information regarding developmental details of the megasporangium. The formation of a single sporogenous cell, as generally observed, and absence of any parietal cells, coincides with the typical routine in orchids, but anomalous conditions appeared in several ovules where two mother-cells were found either contiguous or with nucellar tissue lying between. The figures are suggestive of two archesporia side by side, but the ultimate fate of these cells was not determined. Four megaspores were usually formed, although dividing walls between them were wanting; owing to disintegration of three of the nuclei, the chalazal nucleus alone persisted to become the nucleus of the embryo sac. Evidence in favour of double fertilisation is adduced.

A BROCHURE dealing with the cultivation of fibre plants in India has been issued as Bulletin No. 15 of the Agricultural Research Institute, Pusa. There is a noteworthy division into peasants' crops, capitalists' crops, and fibres worth experimental attention. The first category comprises jute, *Hibiscus cannabinus*, *Crotalaria juncea*, and cocoa-nut; the second includes rhea, agave, Sansevieria, and flax, while plantain and sida fall into the third category. The cultivation of jute has not spread to any appreciable extent beyond the provinces of Bengal and Assam. *Hibiscus cannabinus* is preferred to jute in certain regions, notably the Vizagapatam and Kistna districts in Madras, because it requires less water. Sann hemp, *Crotalaria juncea*, thrives in districts of moderate rainfall; there is an established industry in the fibre in parts of the Central and United Provinces and of Assam, but the plant is more frequently grown to supply green manure or fodder.

THE principal article in *Symons's Meteorological Magazine* for February is devoted to the "Proposed Imperial Meteorological Organisation," discussed at an informal conference of meteorologists at the Winnipeg meeting of the British Association last year. The circular letter drawn up by the committee then appointed for transmission to meteorological authorities of the British Empire, inviting cooperation in contributing data on a common plan for publication by a central agency, is reprinted, and states that, primarily, information is required as to pressure, temperature and rainfall, and their fluctuations from the normal, and it is suggested that the form adopted by the Solar Commission of the International Meteorological Committee, whose headquarters at the present time are in London, in connection with the Solar Physics Observatory, should be followed. Monthly tables relating to the climate of different parts of the British Empire have appeared in *Symons's Meteorological Magazine* for many years; the editor heartily welcomes the establishment of a more general system, under official auspices; at the same time, he does not think that a new system of expressing meteorological observations is desirable. The meeting at Winnipeg expressed an opinion in favour of the use of absolute units for pressure and temperature; for the present, however, the circular states, it is not proposed to ask the various authorities to come to any final decision upon the point.

FROM the February Bulletin of the American Mathematical Society we learn that the Göttingen Academy of Sciences has awarded 5*l.* to Dr. A. Wieferich, of Münster, who has shown that the equation $x^p+y^p=z^p$ cannot be solved in terms of positive integers, not multiples of p, if 2^p-2 is not divisible by p^2. The announcement is followed by the comment:—"This surprisingly simple result represents the first advance, since the time of Kummer, in the proof of the last Fermat theorem."

IN the *Annals of Mathematics* (October, 1909) Mr. Frank Gilman discusses the theory of floating tubes as applied to the measurement of currents in open channels of water. The method was first described by Mr. T. A. Mann in a paper communicated to the Royal Society in 1779, and was used by R. T. Krayenheff in Holland (1813), M. de Buffon on the Tiber (1821), Destrem on the Neva (1835), and Francis in America (1852). The tubes ranged from 6 feet to 10 feet in length, and were allowed to float down the stream over a measured course of 70 feet. Other experiments mentioned are those of Captain Cunningham in India (1874–9), of which a detailed discussion is given in the paper, M. A. Graëff (1883), and Messrs. Humphreys and Abbot on the Mississippi River (1851–76).

THE University of Illinois has established an engineering experiment station to carry on investigations along various lines of engineering. Especial attention has been paid to problems bearing on fuel, and the two last bulletins issued deal with this subject. The first of these, by J. M. Snodgrass, is on fuel tests with house-heating boilers. Central heating by steam is more common in the United States than in this country, but the figures given are not without interest over here. The fuels used, of which complete analyses are given, included anthracite, gas coke, bituminous coal, and briquettes of various kinds. The tests were very complete, and deal with questions of efficiency, cleanliness, cost of control, smoke, and soot. The boiler efficiencies determined varied from 45 to 66 per cent. The experimental data are discussed in a very complete manner, especially from the cost point of view. The only point open to criticism is the unnecessary number of significant figures in the experimental results. Thus we find the calorific value of a coal given as 14,229 B.T.U. per lb., and boiler efficiencies are given to 0·01 per cent. Three significant figures in the calorific value probably represent the limit of accuracy attainable in such experiments when the sampling difficulties are taken into account; an accuracy of 1 in 14,000 in a thermal measurement is certainly unattainable.

THE second bulletin, by S. W. Parr and Percy Barker, deals with the occluded gases in coal. These experiments are of practical importance in two directions, first as bearing on the spontaneous combustion of coal, and secondly as showing how to prevent deterioration of stored coal. Coal commences to give off inflammable gases as soon as it is mined, and at the same time absorbs oxygen from the air, both these changes taking place with greater rapidity the finer the state of division of the coal, and both being almost entirely suppressed when the coal is submerged in water.

THE *Zeitschrift für physikalische Chemie* (January 25) contains a paper, by J. T. Barker, on the determination of the vapour pressures of toluene, naphthalene, and benzene at temperatures ranging from −78° C. to 25·8° C. At the lower temperatures the statical method is not sufficiently exact, and hence the vapour pressures were measured by saturating pure oxygen, prepared electrolytically, with the vapour of the substance, the latter being maintained at a constant temperature. The amount of vapour carried away by the oxygen was determined by combustion, full details being given of the precautions necessary for exact working. The method was shown to be capable of measuring vapour pressures down to 0·005 mm. of mercury. The experimental results were compared with Nernst's formula for the calculation of vapour-pressure curves, and for toluene, naphthalene, and benzene; the agreement was found to be satisfactory.

AN interesting article appears in *Engineering* for February 25 giving particulars of a new shrinking and tempering shop for guns at Woolwich Arsenal. Modern built-up guns have steel tubes and liners which require oil-hardening, and as these guns are sometimes of great length, it will be understood that adequate means must be provided for lifting the guns to considerable heights. It was decided that the new building should be 300 feet long in the clear (the first part to be constructed being 150 feet), 60 feet wide, and 90 feet high from the floor-level to the gantry rail. It was also stipulated that an electro-hydraulic travelling crane should be installed capable of lifting 120 tons, and of travelling with its load at a speed of 75 feet per minute, the speed of the cross traverse under similar conditions being 35 feet per minute. Another requirement of this crane is ability to lower a weight of 60 tons at a speed of 500 feet per minute, this being of great importance on account of the necessity of dipping the guns rapidly into the oil in the process of hardening. Two deep pits, each 11 feet in diameter, are provided for oil-hardening tanks; also one shallower overflow pit, a driving pit 18 feet in diameter with an anvil bottom, and a shrinking pit.

MESSRS. CASSELL AND COMPANY, LTD., have commenced the publication, in fortnightly parts, sold at one shilling net each, of Mr. Richard Kearton's "Nature Pictures." The illustrations are beautifully reproduced, and are accompanied by descriptive text. The work will be completed in twenty-four parts, and we propose to review it when the serial publication is complete.

A SECOND edition of an essay entitled "The Finest Walk in the World," by Miss B. E. Baughan, which originally appeared in the *Spectator*, and was published recently in pamphlet form with numerous illustrations, has been issued by Messrs. Whitcombe and Tombs, Ltd., of Addle Hill, Carter Lane, London. The walk, some thirty-three miles in length, is in the neighbourhood of the celebrated Milford Sound, in the south-west corner of New Zealand. Judging from the beautifully reproduced photographs and the enthusiastic descriptive text which accompanies them, the walk must reveal a succession of panoramic views of Nature at her loveliest.

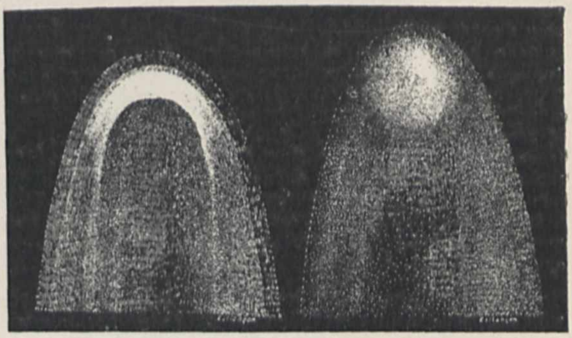
THE annual report of the board of regents of the Smithsonian Institution, showing the operations, expenditures, and condition of the institution for the year ending June 30, 1908, has been received. As usual, the general appendix of the volume, running to some 684 pages, will make the widest appeal to readers. It contains a representative selection of papers and addresses by distinguished men of science dealing with notable current scientific researches. Some of these are translations into English from German, French, and Swedish publications, others have appeared in NATURE from time to time, and the remainder are from American and British authors, some being original, while others are reprints. The following contributions may be mentioned:—Sir Joseph Thomson's Adamson lecture to the University of Manchester, on the light thrown by recent investigations in electricity on the relation between matter and ether; Prof. J. W. Gregory's contribution to the Congrès géologique international, Mexico, 1906, on climatic variations: their extent and causes; Prof. J. Joly's address to the geological section of the British Association at Dublin in 1908, on uranium and geology; Captain H. G. Lyons's lecture to the Royal Geographical Society, on some geographical aspects of the Nile; Prof. Ronald Ross's address to the Oxford Medical Society in 1906, on malaria in Greece; and Prof. Silvanus P. Thompson's Kelvin lecture of 1908 (abridged and revised by the author), on the life and work of Lord Kelvin.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN MARCH:—

March 3. 12h. 0m. Venus stationary.
7. 0h. 39m. Uranus in conjunction with the Moon (Uranus 3° 34′ N.).
8. 9h. 17m. Venus in conjunction with the Moon (Venus 11° 52′ N.).
10. 6h. 0m. Vesta in conjunction with the Moon (Vesta 1° 9′ N.).
13. 2h. 45m. Saturn in conjunction with the Moon (Saturn 0° 58′ N.).
15. 19h. 17m. Mars in conjunction with the Moon (Mars 1° 16′ N.).
18. 17h. 0m. Venus at greatest brilliancy.
25. 18h. 21m. Jupiter in conjunction with the Moon (Jupiter 2° 31′ S.).
30. 18h. 0m. Jupiter at opposition to the Sun.

COMET 1910*a*.—In these columns last week reference was made to two drawings, of comet 1910*a*, which are now reproduced from the *Comptes rendus* (No. 7, p. 370, February 14). They were made by M. Esclangon, and illustrate the remarkable change which took place in the appearance of the comet's head between January 22 and 30.



January 22. January 30.

M. Esclangon points out that such apparent changes may be produced in two ways:—(1) by actual changes in the comet itself; (2) or by the different angles at which it is presented to the observer. While great real changes undoubtedly took place in comet 1910*a*, a certain proportion of the apparent change can be explained by the different aspect, for on January 22 the angle made by the tail with the line-of-sight (comet-earth) was 96°, whilst on January 30 it was 133°; but, apart from this, there was a real change in brightness and in the condensation of the nucleus consequent upon the comet's recession from the sun; on the former date its distance was about 0·25, on the latter about 0·55, astronomical unit.

M. J. Comas Sola also made a special study of the figure of the comet, and gives his results in the same number of the *Comptes rendus*. He remarks that the tail was always bifurcated, as though the nucleus formed a screen to the repulsive force acting on the vapours, and at its greatest length extended to a distance of 50°. Photographs taken at the Fabra Observatory show the details very well, but are not suitable for reproduction. Special attention was paid to the secondary tail on the left of the comet, which was much fainter than the primary, and extended to the opposite side, that is, towards the sun. This tail was *concave* to the direction of the motion, and it is this point that M. Sola discusses. He attributes the concave form to the differential action of the gravitational forces of the sun and the nucleus and the repulsive action emanating from the sun. The greater number of particles are repelled and form the principal tail, but others, depending upon their nature, will not be driven away entirely, and will become attracted towards the sun. The finest of these will be disseminated into space, but the heavier ones will, in falling towards the sun, be attracted by the nucleus, and thus produce the observed form concave relatively to the comet's motion; those falling into the nucleus will be again expelled, but others of which the velocity sunwards is too great will rush past the nucleus and form the fan seen on the side of the head nearer the sun. This hypothesis admits of two tests:—(1) before perihelion the concavity should not precede the nucleus; (2) spectroscopic investigation should show the two tails, at a distance from the nucleus, to differ chemically. M. Sola gives a formula by which the acceleration of the different particles might be computed on the assumption that the forces he assumes are all active, but the photographs of comet 1910*a* do not permit of its application.

FIREBALL OF FEBRUARY 17.—Mr. W. F. Denning writes:—"A considerable number of reports have been received concerning the appearance of this brilliant object. It was seen so far east as in Essex and Kent, and observers in Gloucestershire, Somerset, Devon, and Glamorgan witnessed the descent of the fireball under a more brilliant aspect. The long endurance of the trail was one of the most noteworthy features, and reminds us of the remarkable meteor of February 22, 1909, which left a streak for three hours.

"From the best observations it appears that the fireball of February 17 last descended in a nearly vertical path over a point about twenty miles north-west of Land's End, Cornwall. That its height was approximately eighty-eight to forty-six miles appears very probable, but observations would be valuable from Cornwall and the south coast of Ireland.

"To have created so brilliant an effect in the evening twilight the meteor must have been one of the very largest type, and the shower in Auriga from which it was presumably directed is one of extremely interesting character. Meteors of great size and startling brilliancy are more frequent in the early evening than at any other period of the night, and this is a circumstance to which the writer has several times directed attention."

It is reported that a brilliant meteor, as bright as Venus, was seen from many parts of Yorkshire soon after sunset on Tuesday last, March 1.

HALLEY'S COMET.—In an article on Halley's comet which appeared in the *Times* of February 24, the writer states that the comet is likely to be at its best, as a display, during the last ten days of May, when it will be an evening star and near to the earth. He also suggests that between March 11 and April 24 the comet will probably be unobservable, being too near the sun as seen from the earth. On the latter date it should become visible as a morning star, rising just before dawn; but while its intrinsic light will then be nearly at its maximum, its apparent brilliancy will suffer on account of the distance from the earth. After the transit on May 18, the comet will again become an evening star, and, being then much nearer the earth, should be seen at its best. During the transit Mr. Evershed is hoping to employ both heliograph and spectroheliograph at the Kodaikanal Observatory to obtain records of the comet's nucleus. That this contains a large amount of solid matter is rendered probable by the endurance of the comet for at least 2000 years; simple vapour would scarcely hold together for so long, and could not be expected to disseminate and lose entirely the amount of matter that has been poured forth by Halley's comet even during its known career. A photograph taken at Greenwich Observatory on January 30 showed a fairly defined nucleus surrounded by a large diffused coma, and a very faint tail.

PIDOUX'S COMET, 1910*b*.—No further official news of the comet discovered by M. Pidoux at Geneva on February 20 is to hand, nor had any further observations been reported to the *Astronomische Nachrichten* up to February 25; but according to a Geneva correspondent of the *Daily Chronicle* M. Pidoux discovered the new comet photographically whilst photographing Halley's comet, and confirmed the discovery visually. He says the new comet is V-shaped, and travelling at a great speed in a south-west direction; also that it is brightening, and, given good weather, should become a naked-eye object in a few days. No magnitude is mentioned.

A NAKED-EYE SUN-SPOT GROUP.—A remarkable group of spots has been observed on the solar disc during the past fortnight. Following a pair of spots of moderate size, a small spot was seen to come round the eastern limb on February 17, and on February 19 developed into a group. This group increased in numbers and extent until, on February 23, the length of the affected area, measured along the greatest diameter, was about one-seventh of the solar diameter, roughly 120,000 miles. On March 1 most of the group had passed over the western limb, and there was a low bank of prominence matter, seen in the C line of hydrogen, lying above its position on the limb. The visual observations at the Solar Physics Observatory, South Kensington, showed that a little to the north of the spot disturbance there was a bright trifurcated prominence on the limb, which changed its form considerably between 10 a.m. and 1 p.m. Mr. J. H. Elgie reports having seen the above spot group with the naked eye on February 25.

THE BRENNAN MONO-RAIL SYSTEM.

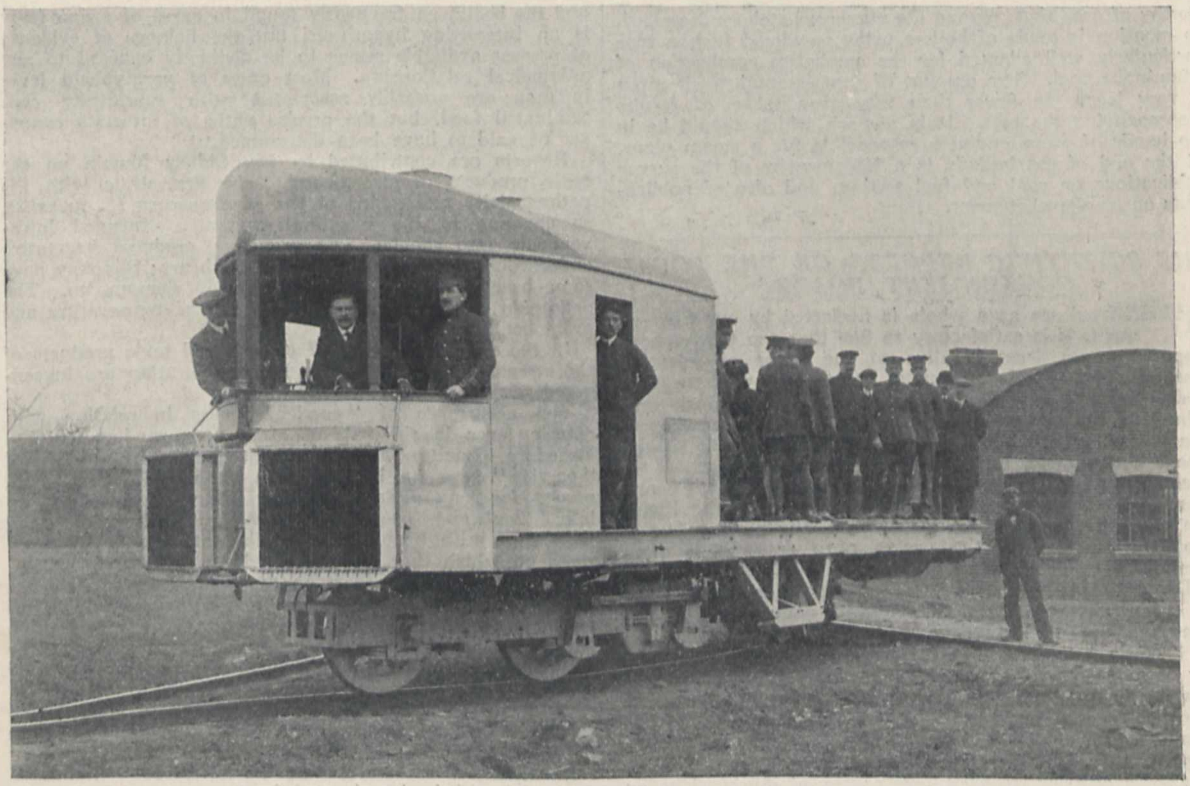
A LARGE company of engineers and others interested, including representatives of the Admiralty and of the War Office, assembled at the Brennan Torpedo Works, near Chatham, on Friday, February 25, to witness a demonstration of Mr. Brennan's mono-rail vehicle. The vehicle shown, which is the first of its kind, has been designed for rough military purposes, not for high speeds, and the trials on this occasion were intended to show its adaptability for this kind of work. A general description of the car and the experimental track appeared on p. 79 of our issue for November 18, 1909, to which we may refer our readers, supplemented with the illustration now shown of the vehicle standing on one of the sharp curves. In this illustration may be noticed the radiators for cooling the circulating water required for the petrol motors, these radiators being secured to the front of the machinery cab; the front bogie with its two wheels, the rear wheel being driven by side rods and balanced cranks from one of the two electromotors; also one of the side chocks, on which the car may rest when required for unloading or other purposes. There is a chock on each side of the car. Mr. Brennan is the centre figure in the machinery cab.

The car first made its appearance from the pier, carrying a number of large packing cases and three or four men, and was brought to rest. Then, running on to the circular track of 105 feet radius, the speed was gradually accelerated to twenty miles per hour, the car inclining inwards automatically so as to counteract the effect of centrifugal force. It is of interest to note that the load was simply laid on the flat platform of the car, without being secured in any way, and that there was not the slightest tendency to disturb the position of any of the packing cases while on the curve, thus showing the perfect balance maintained by the gyroscopes. While stopping on the curve, the angle of heel gradually diminished, and the car platform was level on rest being attained.

The operation of unloading in the field was then shown. While the normal action of the gyroscopes is to maintain the car platform level, the driver can exercise control so as to cause the platform to incline to either one side or the other. With the car at rest on the curve, some packing blocks were laid on the ground reaching to within about a foot of the chock on one side of the car. The driver then inclined the car so that the chock rested on the packing blocks; some planks were laid resting on the ground at one end and against the car platform at the other, so as to extend the inclined plane of the platform down to ground-level. The packing cases were then easily shoved off without the assistance of any tackle whatever. On unloading being completed, the driver caused the car to recover level immediately. Mr. Brennan has not yet published a complete description of the mechanism for bringing the gyroscopes back to their central position, certain patents having been applied for and not yet granted.

We then had an opportunity of taking a run round the circle. All passengers stood, and, despite the fact that there was nothing to take hold of, perfect steadiness of equilibrium was experienced by everyone. The angle of heel inwards we estimated to be about 10 degrees on this trip. An exhibition of the vehicle taking sharp curves followed, the minimum radius being 35 feet, after which we had a trip at high speed down the straight portion of the track and back again. Complete success attended all the trials, and Mr. Brennan is to be heartily congratulated on the results.

From our previous description of the track it will be understood that its simplicity renders it very suitable for military purposes. The short cross-sleepers are simply laid on the ground without ballast, and we noted on this visit that, at one part of the straight line, longitudinal sleepers had been used. At the factory entrance a short part of the line is flush with the surface of the macadam, illustrating the value of the system for tramway work. It is intended to put in hand one or more trailers to be coupled to the present vehicle, in order to show the practicability of running such vehicles on trains.



The Brennan Mono-Rail Vehicle.

THE FUEL QUESTION IN THE UNITED STATES.

AN important department of the United States Geological Survey is that devoted to fuel. More than 400,000,000 tons of coal, valued at above 106,000,000*l.*, were raised in 1908, nearly the whole of which was consumed in the country, and this department has made numerous researches as to the best methods of utilising this coal. The information acquired is published from time to time in the form of bulletins, most of which are supplied free or at a nominal cost. Four bulletins recently issued, Nos. 373, 382, 383, and 385, may be taken as indicating the scope of the work done. They are entitled "The Smokeless Combustion of Coal in Boiler Plants," by D. T. Randall and H. W. Weeks; "The Effect of Oxygen in Coal," by D. White; "Notes on Explosive Mine Gases and Dusts," by R. T. Chamberlin; and "Briquetting Tests at the United States Fuel-testing Plant, Norfolk, Virginia, 1907–8," by C. L. Wright. The paper on briquetting is chiefly of interest to the mine-owners and coal-users of Virginia, although the summary of the recent literature on briquetting possesses a wider value. The work described by R. T. Chamberlin in the memoir on explosive mine gases and dusts had only just commenced when, in December, 1907, a series of unusually disastrous explosions took place in the Naomi, Monogah, and Darr mines of Pennsylvania and West Virginia. This led to a diversion of the original inquiry, the gas and dust concerned in these explosions being subjected to a detailed examination. Special attention was given to the part played by the methane evolved from the coal in the production of these explosions, this gas being more rapidly evolved the finer the state of division of the coal. After this emission of methane had gone on for some time the dust was less readily ignited, and experimental evidence is given showing that the fresh dust is more dangerous than old dust.

The memoir by Mr. D. White, on the effect of oxygen in coal, proves, from the calorimetric point of view, that high oxygen is practically equivalent to high ash. It is also shown that the ratio of hydrogen to oxygen is the best measure of the coking efficiency of the coal, and the effect of the oxygen on the weathering of the coal is also discussed.

The bulletin by Messrs. D. T. Randall and H. W. Weeks, on the smokeless combustion of coal in boiler plants, is of especial interest in the United States, where the regulations against the production of smoke are severe, and strictly enforced. Between 400 and 500 steam plants in thirteen of the larger cities were visited, the data from 285 plants being made use of in this report. The general conclusion is that the smokeless combustion of bituminous coal is possible, and there are many types of furnaces and stokers that are operated smokelessly. The guiding principle is that stokers or furnaces must be set so that combustion is complete before the gases strike the heating surface of the boiler. The plant must be designed for the type of coal it has to burn; no one type of stoker is equally valuable for burning all kinds of fuel. It is worthy of note that, among the numerous stokers described, no mention is made of boilers using powdered fuel, a type particularly well adapted for the smokeless combustion of bituminous coal. The amount of experimental work given is very large, no fewer than fifty-seven tables of results accompanying the text. It is a work which should be in the hands of every engineer responsible for a steam plant. At the end of the bulletin is a bibliography of the survey publications on coal and fuel testing, and also of publications on smoke abatement.

THE SCIENTIFIC REPORTS OF THE LOCAL GOVERNMENT BOARD.[1]

WHEN science as a whole is neglected by our Government, it is satisfactory to find that one Government Department at least is alive to the value of scientific research, and is able by annual grants to investigators to assist research and to produce the admirable work contained in the reports under review. It may be hoped, apart from other considerations, that the example of the Local Government Board may serve a useful purpose in encouraging similar work by other Government Departments. These reports of the Medical Officer of the Board are now being issued much earlier than previously, a fact of moment, for the practical value of a research is often diminished by delay in publication.

Dr. Andrewes furnishes a second report on the bacteria of sewer air. He finds the bile-salt neutral red lactose agar medium of McConkey well fitted for the detection of bacteria belonging to the *B. coli* group. In the drain air of a large public institution and of a private dwelling sewage bacteria can be readily demonstrated, but their presence is of a highly intermittent character. The determining cause of the access of sewage bacteria to drain air appears to be droplet contamination from splashing. Dr. Andrewes and Dr. Horder have continued observations on the defences of the body against the pyogenic cocci, commenced last year by Drs. Andrewes and Gordon, and their joint report contains matter of much interest.

In view of outbreaks of cerebro-spinal fever, Drs. Gordon and Horder investigated the relative efficacy of the various anti-meningococcus sera on the market; the sera tested on animals possessed practically no curative or prophylactic value. Treatment with a vaccine, however, gave some promising results. It is to be noted that Flexner and Jobling have obtained very encouraging results in the treatment of epidemic cerebro-spinal fever in man with anti-meningococcus serum.

Dr. Savage submits reports dealing with mastitis in cows ("garget"). Some 70–75 per cent. of the cases are associated with a streptococcus having special characteristics, and termed the *S. mastitidis*; but it is significant, and throws doubt on the specificity of the organism, that the same streptococcus was found in milk from unaffected quarters of the udder. The explanation may be that, as in other microbial diseases, the organism becomes pathogenic only under special conditions. The streptococci present in cases of human sore throat were also investigated, and were found to be of the *S. anginosus* type.

These two streptococci, morphologically and culturally, are indistinguishable, but show marked differences in their pathogenicity on animals. Thus the mastitis variety is non-virulent to mice and other rodents, but is capable of inducing a mastitis in goats; the anginosus variety, on the other hand, is virulent to mice, but fails to induce mastitis in goats. Dr. Savage therefore suggests that it may be possible to determine whether streptococcal outbreaks of human throat disease are due to milk by the capacity of the streptococci of the human disease to cause mastitis in goats by infection of the teats.

Dr. Savage has also continued his investigations on the cultural reactions and on the presence of bacilli of the Gärtner group in the intestinal tract of animals, and in a second report discusses the presence of paratyphoid bacilli in man. It is pointed out that the hog-cholera bacilli are indistinguishable from paratyphoid types, and the suggestion of a connection between paratyphoid fever in man and the bacilli so frequently found in cases of swine fever is an interesting hypothesis, but the balance of evidence at present available seems to be distinctly opposed to any ætiological relationship. Most cases of paratyphoid fever in man are probably associated with specifically contaminated food, but the precise paths of infection cannot yet be said to have been determined.

Reports are contributed by Dr. Sidney Martin on the toxic products of streptococci. The first deals with the pathogenicity and toxins of the streptococcus (*S. faecalis*), so common in the intestinal contents. Injected intravenously into rabbits, this organism produces vegetative endocarditis of the mitral valve of the heart; this may have some bearing on the ætiology of acute rheumatism. The endotoxin on inoculation produces fall of temperature and great bodily weakness.

In the second the mode of growth and toxic products of the streptococcus (*S. pyogenes*) of suppuration are investigated.

The occurrence of "carrier" cases in relation with enteric fever is the subject of a memorandum by Dr. Theodore Thomson and Dr. Ledingham. The problem of "carrier" cases, *i.e.* individuals in whom the typhoid bacilli persist for long periods after an attack of enteric fever, is a difficult and serious one. Treatment with vaccines and with sour milk have failed to eliminate the bacilli from cases on which they have been tried.

A very important report on the prevalence and sources of tubercle bacilli in cows' milk is contributed by Prof. Delépine. The conclusions are based on an examination of 5320 samples, and 474, or 8·9 per cent., proved to be tuberculous. Various administrative measures are discussed for the eradication of bovine tuberculosis. Details of experiments on the effect of the storage of glycerinated vaccine lymph at temperatures below the freezing point are contributed by Dr. Blaxall and Mr. Fremlin. Cold storage at $-5°$ C. for six months in no way diminished the activity of the lymph, and for two years only brought about a reduction in activity of about 2 per cent.

This necessarily brief survey of the contents of these volumes may, it is to be hoped, direct attention to the important researches carried out for the Local Government Board, and prevent the papers from being overlooked by those who are carrying out work in the same fields.

R. T. Hewlett.

SCIENTIFIC ACTIVITY IN NEW ZEALAND.

THE Philosophical Institute of Canterbury, New Zealand, is one of several very active scientific societies in Australasia. The annual report for the year 1909, presented to the annual meeting held last December, is a record of the continued success of the institute in its scientific undertakings. During the year the publication of the results of the expedition to the sub-Antarctic islands of New Zealand was steadily proceeded with under the editorship of Dr. C. Chilton. The reports upon the work will consist of two quarto volumes of about 400 pages each, and will be illustrated with numerous plates (some coloured), photographs, and text-figures; they will be

[1] Thirty-seventh and Thirty-eighth Annual Reports of the Local Government Board, 1907–8 and 1908–9. Supplements containing the Reports of the Medical Officer for 1907–8 and 1908–9.

accompanied by a large coloured map of the Antarctic and sub-Antarctic regions, showing the ocean depths as ascertained by recent expeditions.

Valuable scientific and economic work in botany has been carried on by Dr. Cockayne during the past two years. Although a great deal has been done in the way of establishing sanctuaries and national parks in order that the native fauna may be preserved for all time, the importance of placing on record their present ecological condition can hardly be overestimated. It is hoped that at some early date the Government may see its way to authorise Dr. Cockayne to proceed further with the botanical survey of the Dominion.

Largely owing to the representations of the institute, combined with those of the Otago Institute, the position of the memorial to the late Sir James Hector has been made satisfactory. Owing to the action of the Government in granting a generous subsidy, ample funds will be at the disposal of the committee for establishing a memorial that will be worthy of Sir James Hector's long and distinguished services to the cause of science in New Zealand. Observations in connection with the Arthur's Pass Tunnel were continued throughout the year. Temperature readings have been taken every ten chains and specimens collected. Early last year a committee was formed for the purpose of investigating systematically the artesian system of Christchurch and the neighbourhood. The committee has held several meetings, and has taken preliminary steps for ascertaining the extent, depth, and geological relations of the water-bearing strata, and for the examination of physical, chemical, and biological properties of the water obtained from them. Two papers by Dr. Farr and Mr. D. C. H. Florance, on the radium emanation contained in the artesian water and on the effect of the water as it comes direct from the well on trout and other fish, have already been laid before the institute.

A committee was appointed to consider the Animals' Protection Act, and to suggest amendments with the view of giving more effective protection to the native fauna of the Dominion. A conference was held with a similar committee appointed by the Canterbury Acclimatisation Society, and a number of recommendations were made which received the approval of the council. It is intended to submit the proposals to other institutes for their consideration, and if they meet with approval to bring the matter under the notice of members of Parliament and of the Minister for Internal Affairs. It is hoped later to send a party to the Chatham Islands for purposes of scientific investigation.

It is evident that the institute is not only encouraging interest in science by its monthly meetings, but is also actively engaged in promoting the progress of natural knowledge.

THE WORK OF LORD KELVIN IN TELEGRAPHY AND NAVIGATION.[1]

LORD KELVIN'S work was great and many-sided. We might compare it to the cathedral in some crowded mediæval city, where no place can be found commanding a general view. You approach by one narrow street or another, seeing from each only some portion of a particular face of the building. The Kelvin lecturer has, as it were, to select his view-point, conscious that he must concentrate his attention on what is, after all, but a small part of a gigantic whole. The lecturer might, for instance, take up the mathematical work of Kelvin in the theory of electrostatics, in the theory of magnetism, in the theory of elasticity, in hydrodynamics, in the wave theory of light; his contributions to thermodynamics, which included the establishment of an absolute scale of temperature and the enunciation of the principle of the dissipation of energy, his experimental work on the electrodynamic quality of metals, his speculations on the structure of matter, his views on the age of the earth, his share in fixing the electrical units; or, on the more practical side, his electrical measuring instruments, from the electrometers of the early days to the ampere balances and wattmeters which he designed when the need for such instruments became apparent with the growth of electrical engineering. Any one of these subjects, or others that might be named, would provide a more than ample text. To-night I have selected two portions of Lord Kelvin's work as the most suitable to bring before you, namely, his work in submarine telegraphy and in navigation. Both of these are practical matters which appeal to members of this institution. They illustrate well the bent of his genius as an engineer. In both of them he made inventions of first-rate importance—inventions which not only met an immediate requirement, but have stood the test of time; and an additional reason for the selection is the personal one that both in telegraphy and navigation it was my good fortune, as one of his young assistants, to see some of his inventions in the making.

His connection with telegraphy had begun long before, when he was only thirty years of age. It dates from 1854, and to appreciate rightly the part he began to play then I must ask you to go back as far as 1850, the year of the earliest submarine telegraph. It was in August, 1850, that a line consisting of a single copper wire, insulated by gutta-percha, wound on a great reel on the deck of a steam tug in Dover Harbour, was laid from Dover to Calais. There was no sheathing or protection of any sort; the line was what we should now call a bare core, and so light was it that lead sinkers were attached at every hundred yards to ensure its going to the bottom. In a few hours it was cut by the anchor of a fisherman, who took home a piece to show to his family as a curious new kind of seaweed; but during its brief life it gave the operators much food for thought. Accustomed only to the clear, sharp signals of land lines, they could make nothing of those got from the cable, and Mr. Willoughby Smith tells us how at each end of the line it was regretfully concluded that the operator at the other end must have been lunching, not wisely, but too well. This was the earliest experience of the effects of electrostatic induction in retarding the signals and altering their character. The cable is equivalent to an extended Leyden jar of large capacity, and at every application of the sending battery there is a gradual charging up, so that the signal current which arrives at the distant end does not at once reach its full strength; and, further, when the contact with the sending battery stops the current does not at once cease, but tails off slowly as the cable discharges the electricity it has accumulated. The current accordingly arrives in the character of a wave, slowly rising to a maximum value and then slowly subsiding each time a signal is sent.

In a short cable this causes little trouble; it only makes the process of signalling a little slower, but the instruments which serve on land lines may still be used. A successful Dover-Calais cable properly covered with a protecting sheath was laid in 1851, and was soon followed by other short lines. The general character of the electrostatic charge in a cable was explained by Faraday, and it was experimented on by Latimer Clark in a cable, 110 miles long, laid to connect England with Holland; but no one knew then in what manner the retardation of signals to which it gives rise depended on the electrical characteristics or how it would be affected in cables of different lengths or with different dimensions of core. It was in 1854 that Thomson's attention was directed to the subject by Stokes, following on a conversation at the British Association, and in this way began the connection with submarine telegraphy which was to prove of momentous import.

Thomson attacked the problem with characteristic ardour, and in less than twelve days he sent a complete solution to Stokes, which was published in fuller form in the Proceedings of the Royal Society for May, 1855. In this paper he points out that the effect of electrostatic induction is to make the flow of electricity in a cable correspond to the flow of heat in a solid conductor as investigated mathematically by Fourier. He formulates the equations and draws what is called the *curve of arrival*, the curve, namely, which shows in what manner the current gradually reaches its full value, at the distant end of the cable, when contact with the battery is made at the sending end. He shows how the current falls away when the battery is removed and the cable is put to earth; and how, in cables of different lengths but of the same

[1] From the second Kelvin lecture, delivered at the Institution of Electrical Engineers on January 13, by Prof. J. A. Ewing, C.B., F.R.S.

dimensions of core, the time taken by the current to reach any particular fraction of the full value will vary as the square of the length.

This result of the theory was of fundamental importance. It was also, at the time, of particular interest, for the project was then beginning to be mooted of connecting England and America by wire. The only experience available as to speed of signalling was on short cables, and in passing from them to a line 2000 miles long the "law of squares," as it was called, seemed at first to give little prospect that signalling across the Atlantic could be accomplished at a speed that would be commercially practicable.

To lay the cable it was coiled on board two ships of war, the British battleship *Agamemnon* and the United States frigate *Niagara*. On August 5, 1857, the shore end was landed at Valencia, and the *Niagara* began to pay out, the intention being that her section should be laid first and the *Agamemnon* should continue the work after making a splice in mid-ocean; but the paying-out gear was very crude; the brake for maintaining a proper tension in the cable was difficult to regulate, and after 300 miles were laid there was a mishap at the brake and the cable parted in 2000 fathoms. The ships returned to Devonport, the cable was stored for the winter, new machinery was designed, and some 700 miles of fresh cable were manufactured against the next attempt, to be made in the following year.

Thomson had joined the expedition at the request of his brother directors, and was on board the *Agamemnon*. He came back full of ideas as to both the electrical and the mechanical sides of the great problem. On the mechanical side he had worked out, for the first time, the theory of the forces concerned in the laying and lifting of deep-sea cables; this was published almost immediately after his return. Let me give you a brief sketch of the results of this theory.

A cable paid out from a ship going at uniform speed does not hang as a catenary, but takes the form, as it sinks, of a straight line stretching at a uniform slope from the ship's wake to the point far in the rear at which it touches the bottom. This is because each part of the cable in sinking through the water attains almost immediately a constant velocity of descent against the resistance which the water opposes to its motion. Imagine a ball, heavier than water, to be dropped from a ship. It will, after sinking a foot or two, attain a practically uniform velocity, and keep that until it reaches the bottom. Imagine, now, a ship to drop a series of such balls, at regular intervals, while she steams ahead at a steady speed. At any instant the depth through which each ball has sunk will be proportional to the time which has passed since it was dropped, and therefore to the distance run by the ship, and hence a line joining the successive balls will be a line of uniform slope. The continuous cable behaves in this respect like the row of balls, but with this important difference. Each ball sinks vertically; it has no tendency to do anything else; but the cable tends, not only to sink, but to glide along the direction of its own length, just as a rope resting on an inclined plane tends to glide down it. A certain amount of such gliding is desirable, indeed necessary, for it secures that the cable will be laid with a sufficient percentage of slack to accommodate itself to any inequalities on the bottom, and to provide for the possibility of its being raised should that be required. It is the function of the paying-out brake to apply just so much retarding force as will allow the right amount of this gliding to take place, and not too much. As cables are actually laid, there may be 10 or 12 per cent. of slack, and this means a considerable velocity of gliding motion. In a cable of the type which was afterwards successfully laid across the Atlantic, the straight line had a slope of about 1 in 8½—in other words, with a depth of two miles there were seventeen miles from the ship to the place where it touched bottom. On the gliding motion down this long slope the frictional resistance of the water is an important factor; it reduces very much the retarding force needed at the brake. If it were simply a question of holding the cable from gliding down the slope at all, the retarding force would be equal to the weight, in water, of a length of cable equal to the depth. In fact, however, it is about half that, the other half being accounted for by the frictional resistance the cable experiences in gliding down the slope.

In the early summer of 1858 the cable squadron was again ready to put to sea. New paying-out brakes had been devised. Thomson had succeeded, with much difficulty, in getting systematic tests of the conductivity established during the manufacture of the additional 700 miles. Most important of all, he had invented a new signalling and testing instrument which was to make Atlantic telegraphy commercially practicable. This was the mirror galvanometer, the first description of which is found in his patent of 1858.

We have no time to linger over the story of the cable of 1858. This time the two ships, after encountering a storm of great severity, in which the coiled cable suffered severe damage, met in mid ocean, spliced the cable, and began to pay out simultaneously, the *Agamemnon* steaming towards Ireland and the *Niagara* towards Newfoundland. The cable broke when only six miles were paid out. Again the ships met to make a fresh splice, and again the cable failed when some eighty miles had run out. A third attempt promised better, for some 200 miles were laid, when again the cable broke, this time at a place where it had been injured in the storm. The ships returned to Queenstown; Bright, Thomson, and the other leaders, disappointed but not discouraged, advised the Board to order a fresh attempt. Their advice was taken. The ships once more met at the mid-ocean *rendezvous*, and this time success crowned their efforts. On August 5 both ships completed their task, and the ends of the cable were brought to land.

Scarcely had the enthusiasm awakened by this great event begun to subside when it was apparent that all was not well. The Irish end of the cable had been handed over to Mr. Whitehouse, who attempted with little or no success to establish communication by means of his own signalling instruments. It was only when the galvanometer of Thomson was resorted to, with a simple Daniell battery to send the current, that messages were transmitted. The Board, dissatisfied with Whitehouse's action, directed Thomson to take complete charge. Various important messages passed, but the tests showed that the insulation of the cable had broken down; a bad fault developed, which had doubtless been intensified, if not produced, by the high-tension induction coils used by Whitehouse. The signals grew more and more feeble, and in a few weeks the cable altogether ceased to speak.

It never spoke again, and not until 1865 was the attempt made to lay a new Atlantic cable. By that time much had been accomplished. It was in the intervening years that the work of establishing standards for electrical measurement was undertaken by a committee of the British Association. The committee was appointed at the instance of Thomson, and he took a prominent part in its work. Besides this, the cable engineers were busy, and were gaining experience from lines laid in other places. Methods of systematic testing were devised; a type of cable was designed which was better adapted than before to bear the strain of laying, and especially the much severer strain of picking up, and material improvements were made in the paying-out machinery.

In 1865 the *Great Eastern* was available for laying the cable. Thomson, along with Cromwell Varley, went as a consulting expert on behalf of the company. Twelve hundred miles were successfully laid, and then a fault showed itself; picking up was begun, but in manœuvring the ship the cable parted in deep water. Attempts were made to recover it by grappling; three times it was hooked and brought part of the way to the surface, but the shackles used to couple up successive lengths of the grappling rope were too weak to stand the strain. Grapnel, rope, and cable were lost, and the ship returned with the task unfinished, but with everyone now full of confidence, not only that a sound cable could be laid, but that the lost cable could be found and lifted.

In 1866 the thing was done; an entirely new cable was laid with complete success, and then the *Great Eastern* with her consorts proceeded to the lost end of the cable of 1865, and began once more to fish in water more than 2000 fathoms deep. A fortnight passed before the watchers at Valencia saw any sign; then the spot of light began to flicker, and presently the flickerings shaped themselves into letters and words. The cable had awakened to life. A few days more and it too was complete.

Throughout the operations Thomson was in the ship; Varley remained at Valencia. Thanks to their labours, and to those of Mr. Willoughby Smith, the contractors' electrician, the appliances for testing on board ship had been brought to a degree of perfection that left nothing to be desired. By this time it was generally recognised that the credit for Atlantic telegraphy, regarded as an electrical achievement, belonged to Thomson, though in his characteristic manner he would, when speaking of the subject, dwell on the parts played by others. Along with Mr. Canning, the engineer of the expedition, and Captain Anderson, who commanded the *Great Eastern*, he received the honour of knighthood.

For a time his mirror galvanometer remained the only instrument by which conversation could be carried on. He now proceeded to design a substitute for it which should give a record of the successive electric impulses instead of merely exhibiting them to the watchful eye of a skilled clerk. To secure greater power in the movement of the indicator he inverted the function of magnet and coil, making the coil the movable piece and the magnet the fixed piece. The coil was, therefore, made very light; the magnet, which being stationary might now be very heavy, was made exceedingly strong, and was arranged so that the coil lay in an intense field between its poles. The movement of the coil actuated a very light pointer, or rather pen, in the form of a siphon-shaped tube of fine drawn glass, from which ink was deposited on a running paper band. Here we find the earliest example of the moving coil type of galvanometer, often called the D'Arsonval type by those who do not recognise its real origin. It is a type now familiar in many practical instruments for the measurement of direct-current amperes and volts; but an important element in the invention is still to be named. It was essential that the glass pen should write without friction, and Thomson effected this by the happy device of electrifying the ink so that the ink and the paper attracted one another, with the result that the siphon was maintained in a constant state of rapid vibration, alternately advancing to the paper to deposit a minute drop of ink and then springing back, but all the time free to follow, without friction, the movements of the coil in obedience to the electric impulses arriving through the cable. Dynamically the siphon recorder has to satisfy the same conditions as those that determined the design of the mirror galvanometer. It draws on the moving strip of paper a curve of arrival for every one of the successive currents of which the signals are composed.

To this day the recorder remains in universal use as the standard instrument in submarine telegraphy. It has been simplified by the substitution of permanent field magnets for electromagnets, and by the use of an electromagnetic vibrator for the siphon instead of electrification—changes which were made in later years by Thomson himself.

It is time now to turn to Lord Kelvin's work in navigation. Taking the two oldest aids to navigation, the compass and the sounding-line, he revolutionised them both. Where most men would have thought there was nothing left for invention to do he found much. He has earned profound gratitude for appliances which add immeasurably to the security of all who go to sea. He has been called the best friend the sailor ever had; and it is said that a bluejacket was once overheard to remark, "I don't know who this Thomson may be, but every sailor ought to pray for him every night."

It was about 1873 that he began to study the compass seriously, partly because he had undertaken to write an article on it for *Good Words*, and partly because he had occasion to prepare, for the Royal Society, a biographical sketch of his friend Archibald Smith, containing an account of Smith's work on the theory of the perturbation of the compass caused by the magnetism of iron ships. Kelvin's first patent for an improved compass was taken out in 1876.

He found the compass full of serious defects. For one thing it was very unsteady—that is to say, it was liable to be set swinging through a large angle when the ship rolled. Sometimes an attempt was made to reduce this unsteadiness by introducing friction at the pivot, which, in a way, made matters worse by causing the compass to stick, pointing in a wrong direction. Under a mistaken idea of what would lead to steadiness, the card was made heavy and the needles long, and the long needles made it impossible to correct the compass properly for the magnetism of the ship. This was the most serious defect of all. In iron ships, and especially in ironclads, the compass is at the mercy of disturbing influences, which do much to mask the true directive force of the earth's magnetic field. To neutralise these is indispensable; the way to do it, as a matter of theory, had been pointed out, but it was only through the radical change in construction which we owe to Kelvin that it became possible to carry the process into effect.

He recognised that for this purpose the needles must be short. Further, that for steadiness what was wanted was a long period of horizontal oscillation—in other words, small magnetic moment relatively to the moment of inertia of the card; but, to keep the frictional error down, the weight of the card, including the needles, should be small. So he made the card as light as he could get it—a mere aluminium rim tied by silk threads to a small central boss, just as the rim of a bicycle wheel is tied to the nave by wire spokes, and from the silk-thread spokes he hung short pieces of magnetised knitting-needle to serve as the magnets. The result was that not only was the total weight very small, but it was nearly all in the rim, where it is most useful for giving moment of inertia and consequent slowness of period. Magnets and all, the card only weighs 180 grains for a 10-inch size, and yet its period of oscillation is much longer than that of the old standard compass, while its friction error is less.

Another admirable feature of Kelvin's invention was his method of keeping the compass always level and free from pendulum-like oscillation. He hung the bowl, as usual, from gimballs, but with knife-edges instead of the usual round spindles at the trunnions, and under the card he provided a chamber at the bottom of the bowl partly filled with castor-oil. You see this in the glass bowl now on the table. There is a glass partition to separate the place where the compass card stands from the lower part of the bowl, and in the lower part is the castor-oil. Its function is to damp out any oscillation of the bowl that may tend to be set up by the rolling or pitching of the ship, and it does so by dissipating the energy of such swings. At the same time the knife-edge gimballs leave the compass perfectly free to take up a true level.

Another feature is that the bowl and gimballs as a whole is hung from springs to withstand vibration caused by the action of the screw, or in warships by gun-fire.

Now as to the correction for the magnetism of the ship. Let me indicate very briefly the nature of that problem, and how it is solved.

An iron ship is a great magnet, or rather a great aggregate of many magnets. Her magnetism at any instant springs from two causes. First, there is the more or less permanent part, which she takes up first when she is built; it depends to a great extent on how her head lay while she was on the stocks. Then there is the induced part, which changes with every change of course—a transient effect due to the induction of the earth's magnetic field. Strictly speaking, the induced magnetism is not entirely transient, nor is the other by any means entirely permanent; but the ideal division into transient and permanent is a highly useful one provided we understand the limitation within which it is to be accepted. Now think of what happens when the ship is "swung," that is, turned so that she heads successively on all points. The permanent magnetism will cause an error of the compass which will be of the same nature as you would find if you placed a compass needle on a fixed pivot and disturbed it by turning a bar magnet slowly round a vertical axis. This error will reach a maximum twice in the revolution, once to one side and once to the other side—in other words, once in each semicircle. Hence it is called the semicircular error. The permanent magnetism of the ship has a vertical component, and this causes not only semicircular error, but also a heeling error, namely, a deflection of the compass when the ship inclines to either side.

By a combination of three sets of correcting magnets, two horizontal and one vertical, Kelvin obtained complete neutralisation of the disturbing effect of the ship's permanent magnetism, both as respects semicircular error in change of the ship's course and heeling error as she heels or rolls. From time to time, if the condition of perfect compensation is to be maintained, the position of these various correctors has to be altered, because of changes which take place in the so-called permanent magnetism of the ship. The navigator has always to be on the look-out for the gradual development of errors from this cause, however perfectly the first adjustment has been carried out.

We have next to consider the effects of induced magnetism. The most important of these arise from the fact that the ship is a long body of magnetisable material turning in a horizontal plane, and therefore subject to the inductive influence of the horizontal component of the earth's magnetic field. Think of what would happen if we were to take a pivoted compass needle and place it above or below a bar of soft iron, and slowly turn the bar round in a horizontal plane. We are to think of the bar as having no appreciable magnetic hysteresis, so that in every position it is the induced effect only with which we have to do. What will be the nature of the deviation? When the bar points north, and again when it points south, there is no deflection of the needle, for though the magnetism of the bar is then at its strongest, the field due to it is in the line with the undisturbed earth field; also when the bar points east or west there is no deflection, for the bar then takes up no magnetism; but between these points, namely, when the bar is pointing N.E., S.E., S.W., or N.W., the deflection is at its maximum. So in a ship's compass this error, due to the purely transient magnetism induced by the horizontal component of the earth's field, has its maximum on these four courses, once in each quadrant, and for that reason it is called the quadrantal error.

It is due, as we have seen, to the ship's being a long body, extending fore and aft, and it is corrected by balancing this excess of fore and aft iron by other iron, placed quite near the compass and on either side of it. The two balls which you see on the side of the Kelvin binnacle are the correctors for quadrantal error. They are adjusted, in the first place, by selecting a suitable size of ball, and then placing them nearer to or further from the compass until, on swinging the ship, the quadrantal error disappears. The possibility of correcting the quadrantal error in this way had been pointed out by Airy as early as 1840; but with the old form of compass card and needles it could not be done, because of the excessive length and large magnetic moment of the needles. To apply the method to a compass of the old pattern would have needed globes of impracticable size, not a few inches in diameter as these are, but weighing tons. Kelvin, with his short needles on a light card, made it possible to carry out the process, and so gave the world, for the first time, a compass that would point truly to the magnetic north, notwithstanding all the perturbations due to permanent and induced magnetism in the iron of the ship.

One more of these disturbing causes remains to be mentioned. The vertical component of the earth's field induces magnetism as well as the horizontal component, and gives rise to an additional error of two kinds, namely, a further semicircular error and a further heeling error. These are distinct from the semicircular error and heeling error due to permanent magnetism, and the right way to correct them is to fix a bar of soft iron in a vertical position[1] near the binnacle, so that the magnetism induced on it will act as a counter-balance. This is the Flinders bar, so called because its use was pointed out by Captain Flinders as early as 1801. It has generally to be fixed in front of the binnacle, and in Kelvin's compass it is made in several separate lengths of soft iron, which can be put together to make up a bar giving any necessary amount of correcting effect.

The main function of the Flinders bar is to correct the semicircular error due to induced vertical magnetism. So far as the heeling error is concerned it also helps, but in practice it is found convenient to correct a part of the heeling error due to induced magnetism by means of the same kind of permanent magnet correctors as I have already described in speaking of the heeling error due to permanent magnetism, namely, vertical magnet bars placed in a can in the binnacle directly under the centre of the compass card. The number and height of these bars has therefore to be altered from time to time, as the ship moves to regions where the vertical force is different. When the heeling error is fully corrected we escape one cause of the unsteadiness which a compass shows when a ship rolls, for we escape the magnetic cause of oscillation, namely, the alternate magnetic pull to port and starboard; but a purely dynamical cause of unsteadiness necessarily remains, arising from the fact that the point of suspension of a compass card must be placed some way from the centre of gravity to hold the card level against the dipping action of the earth's magnetic field. Consequently, every roll to either side applies a mechanical couple tending to set up oscillation, and if the period of the roll were the same, or nearly the same, as the period of oscillation of the card, the disturbance would become so great as to make steering by compass impossible. It was to secure steadiness in this sense that Kelvin strove to give his compass card a long period of oscillation, recognising that the right way to obtain steadiness was to make the period much longer than the period of the slowest rolling motion liable to occur in a ship, at the same time keeping the friction as small as possible. The problem of securing a steady, frictionless compass was a problem where, as in the invention of the mirror galvanometer, his genius for practical dynamics guided him to the right solution. In the case of the compass it was rendered difficult by the fact that other conditions, apparently antagonistic, had at the same time to be satisfied in order that the correction of magnetic errors might be completely carried out.

The evolution of the Kelvin compass, in its main features, took about five years; but a longer task lay before the inventor in overcoming the professional conservatism of sailors, the objections of the so-called practical man, active hostility in some quarters, and the passive resistance of official inertia. Gradually the compass came to be used in merchant vessels of the best appointed class. Enlightened navigators such as Captain Lecky, the author of the well-known "Wrinkles," became its enthusiastic advocates. Foreign admiralties took it up, and in our own service individual officers were quick to see its merits. Captain Fisher, now Admiral of the Fleet Lord Fisher, was warm in its praise after observing its behaviour in ships under his command, first in the *Northampton* in rough weather and afterwards in the *Inflexible* during the firing of heavy guns in the bombardment of Alexandria. That was in 1882; but it was not until November, 1889, that the superintendent of the Compass Department of the Admiralty was in a position to inform Lord Kelvin that his 10-inch compass was to be adopted as the standard compass for the Navy. This was twelve years after the date of his patent, and more than eleven years after he had laid the invention formally before the First Lord. The way of the inventor, like that of the transgressor, may still be hard, but I trust it is not so hard now as it was then. One does not care to dwell on the spectacle of a Kelvin spending his strength in disheartening effort as the sea beats against a cliff. It is painful to read the correspondence and discussions of these weary years. One does it with increased admiration of the infinite patience which at last secured to us the benefits of his practical genius.

The use of the Kelvin compass may now be said to be universal, except that in the Navy a modified form, due to Captain Chetwynd, with a card immersed in liquid, is taking the place of the Kelvin dry card in the newer ships as being steadier still under gun-fire. The system of correction remains substantially unchanged, and the compass continues to embody the same mechanical features as formed the basis of Kelvin's invention.

In the navigational sounding machine we have another invention of first-rate importance, second only to the compass in practical value to sailors, and remarkable for its extreme simplicity. It was his cable-laying experience that first led Kelvin to take an interest in deep-sea sounding. The process, as then carried out, was a laborious one. The line was a rope an inch and a half in circumference,

[1] That is to say, vertical when the ship is on even keel or perpendicular to the deck.

and though it carried a very heavy sinker, the resistance to its motion through the water was so great that it took a long time to reach the bottom. For the same reason the ship had to be stopped while the line ran out, and, except in shallow water, while it was being heaved in. Many hands were needed, and much time was spent in making a cast. Hence it came about that the operation of sounding, beyond the use of the hand-lead in quite shallow water, was but little resorted to as an aid to navigation, notwithstanding the importance of the indications it could give in such cases as when a ship was approaching land in a fog or in circumstances which made the exact position uncertain, when the depth might be anything up to, say, one or two hundred fathoms.

I have spoken already of Thomson's study of the forces acting on a cable during its submersion. Applying these principles to the sounding-line, he recognised that to make the line slip down quickly it should have the smallest possible and the smoothest possible surface, and this led him to use a single wire of steel—the steel of high tensile strength used in pianofortes. In 1872 he demonstrated the practicability of using wire by taking a sounding and finding bottom at 2700 fathoms in the Bay of Biscay with a 30-lb. sinker and a single wire of No. 22 gauge. He soon devised a suitable drum and winding-in wheel for deep-sea use, and from this was developed later a compact form of navigational sounding machine by which flying soundings are taken without stopping the ship.

In a flying sounding the wire streams out behind, taking an oblique course to the bottom, and the length of wire that runs out is greatly in excess of the depth. To read the depth directly, Thomson invented several forms of depth gauge, the simplest of which is a long narrow glass tube, closed at the top, and coated inside with chromate of silver or some other chemical which is discoloured by the action of sea-water. This tube is put in a protecting case, which is attached near the sinker, and as it descends the increased pressure forces the sea-water up into it, compressing the air, and indicating the depth by the height to which the chemical lining is discoloured. Accordingly, the depth is read off by laying the tube against a scale, when the line is again drawn on board.

This machine has become a standard navigational appliance. The length of wire in common use is 300 fathoms. A strand of seven fine steel wires, which gives greater flexibility, is now substituted for the single wire. It runs out under a regulated tension, supplied by a rope brake, which retards the rotation of the drum on which the wire is wound. When the sinker touches bottom the tension is at once seen to slacken, or rather felt to slacken by a sailor who keeps a little rod of wood lightly pressed against the wire while it runs out; the drum is stopped, and the wire is slowly wound in again by hand, or in the latest naval type by electric motor. Lord Kelvin's final improvements in the machine were made only a year or so before his death; they were, in fact, his last serious inventive work. They include a large horizontal dial for reading the number of fathoms of wire out, and with this it is often practicable to tell the depth very closely without resorting to a depth gauge at all; for in the modern machine the action is so uniform that, at any given speed of ship, a definite relation holds between the depth and the length of wire out, and by finding this relation once for all a table can be prepared by which the speed is known, and so when the length of wire out is observed the depth may be at once inferred. This system is now in regular use in the Navy. A pair of the Kelvin machines stand on the bridge; the wire runs out along a boom at either side and over an ingeniously designed pulley or fair-lead; whenever soundings are wanted, they can be taken systematically and in quick succession while the ship proceeds at undiminished speed, and the depth is called out for the information of the navigating officer almost as soon as the wire has stopped running out. Alike in the Navy and the merchant service, there is no difficulty in making it a matter of routine to keep the sounding machines going incessantly when near shore or within, say, a hundred fathoms in thick weather.

(Dr. Ewing then went on to speak of Lord Kelvin's advocacy of the Sumner or "position-line" method of working out sights at sea, and his tables for facilitating Sumner's method; also his harmonic analysis of the tides and his tide-predicting machine.)

In attempting this account of the work of Kelvin in telegraphy and navigation, I am embarrassed by its volume and its range. The time has proved far too short for a fitting notice of discoveries and inventions so various, so fundamental, so far-reaching in their practical effects. Yet we have dealt only with a very small part of the whole achievement of a man not less remarkable for sustained industry than for outstanding originality—a man incessant in action and in thought—of whom it may be truly said that there is no department of physics on which he has not left an abiding impress.

I have said nothing to-night of the lofty flights of scientific imagination, which are, perhaps, his highest title to fame; but I have said enough to show that Kelvin was no mere philosopher with head in the clouds. He was quick to recognise a real need, quick also to see how the need should be met. He found material for invention in the most commonplace appliances, because his mental habit was in everything to seek for the how and the why and to ask himself in what way the thing might be done better. He had an infinite faculty of taking pains, of adhering to a purpose until he secured its full accomplishment, of going on from improvement to improvement in pursuit of the more perfect result, and with all this a courage and hopefulness that no opposition could damp, that never accepted defeat.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Dr. E. W. Hobson, F.R.S., fellow, tutor, and lecturer in mathematics at Christ's College, has been elected Sadlerian professor of pure mathematics. Dr. Hobson was senior wrangler in 1878, and has been mathematical lecturer in the University since 1884, a lecturer in Christ's College since 1879, and for the last few years Stokes lecturer. His earlier published work related principally to spherical harmonics, Bessel's functions, and other allied functions, together with the cognate subject of the theory of the potential. On these subjects he published a memoir in the Philosophical Transactions of the Royal Society, two memoirs in the Cambridge Philosophical Transactions, and a series of papers in the Proceedings of the London Mathematical Society. About the year 1900 Dr. Hobson began to publish a series of papers dealing with the theory of aggregates, that of functions of real variables, the theories of G. Cantor, and the fundamental principles of mathematical analysis; and in 1907 his treatise on the theory of functions of a real variable, and on Fourier's series, was published by the University Press. Since the appearance of this book he has, during the last two years, published several papers, in which he has given a general convergence theorem, and applied it to questions connected with the representation of functions by means of series of Sturm-Liouville functions, Legendre's and Bessel's functions, and to the elucidation and extension of the theory of Hamilton's fluctuating functions. He has also quite recently published papers dealing with Lebesgue's new theory of integration, in relation to the fundamental processes of the integral calculus.

LONDON.—The first annual report of the Military Education Committee on the work of the university contingent of the Officers' Training Corps, which was presented to the Senate on February 23, has been issued. The contingent, which was formed under the authority of a War Office letter dated January 7, 1909, numbered 24 officers and 783 enrolled cadets at the end of the year. Three units are included, an engineer unit of one company, an infantry unit of a battalion of six companies, and a medical unit of three sections of a field ambulance. An application has been submitted to the War Office for permission to organise Artillery and Army Service Corps units, and to augment the medical unit. University College has the largest number of cadets (160), King's College coming second with 132; and the medical schools, especially Guy's (67) and Middlesex (64), are well represented. The report contains much statistical information throwing light on the ages and educational antecedents of London students. As regards the ages of cadets, the largest groups (159 and 151 respectively) fall in the age limits nineteen to twenty and twenty to twenty-one. Of the 783 cadets, 127 were educated abroad—48 in India, 48 in other British dominions and colonies, and 31 in foreign countries. The educational results achieved in the contingent appear to be satisfactory, 232 cadets having already entered for Certificate A and 3 for Certificate B granted by the War Office for military subjects. The first camp was held at Salisbury Plain in August, and the first inspection by Major-General Sir F. W. Stopford, which was held during camp, produced a highly satisfactory report.

IT is announced in *Science* that a department of experimental breeding has been established in the college of agriculture of the University of Wisconsin. Dr. L. J. Cole, of the Sheffield Scientific School at Yale, has been appointed an associate professor of experimental breeding. Dr. Cole will take up his new work shortly, and will conduct investigations in the subject of experimental breeding, with special reference to the laws of heredity and improvement of animal life.

SIR GEORGE GREENHILL contributes some impressions of a visit to Berlin and its educational establishments to the *Engineer* for February 25. The chief object of his visit was to accept an invitation to examine the Militärtechnische Akademie, an establishment devoted to the instruction of officers in the science and manufacture required in modern warfare. Sir George seems to have been deeply impressed with this splendid and efficient institution, which is such as we have not in this country. Sixty officers are under instruction for a course of four years, more complete than is required now for a degree in honours at Cambridge, and their zeal and interest is said to be enthusiastic; it is considered bad form not to give the very best for the glory of the Fatherland. Of special interest was the modern ballistic laboratory established in the last four or five years, under the direction of Prof. C. Cranz. This includes lecture and experimental rooms filled with the most modern apparatus, and alongside a bomb-proof range of 60 metres. Sir George Greenhill seems to have taken delight in showing Prof. Cranz how to apply the six-point contact principle as required for a rifle rest, using for the purposes of demonstration some nails and a broomstick with broom, as a rifle was not for the moment at hand. The principle was given very clearly about 1867 in Thomson and Tait's "Natural Philosophy," but, as Sir George truly remarks, is too scientific for the official expert to grasp.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, February 24.—Sir Archibald Geikie, K.C.B., president, in the chair.—Sir William **Abney**: colour-blindness and the trichromatic theory of colour vision.—W. **Cramer** and H. **Pringle**: Contributions to the bio-chemistry of growth. The total nitrogen metabolism of rats bearing malignant new growths. The nitrogenous metabolism was determined in rats before and after transplantation with a rapidly growing spindle-celled sarcoma. The results show that less nitrogen is necessary to build up a certain weight of tumour tissue than is necessary to build up an equal weight of somatic tissue of the host. No evidence could be obtained that the tumour cells had a higher affinity for nutritive material than the growing cells of the host, or that they secreted substances having a toxic action on the nitrogenous metabolism of the host. The conclusion was arrived at that the cells of the new growth derived the nitrogenous material necessary for the building up of new tissue by a sparing of the protein metabolism, so that a smaller amount was utilised as a source of energy and a larger amount for the building up of new tissue.—W. **Cramer** and H. **Pringle**: Contributions to the bio-chemistry of growth. The distribution of nitrogenous substances in tumour and somatic tissues. Estimations were carried out of the total nitrogen content of rapidly growing transplanted tumours (carcinoma and sarcoma), and of the tissues of the animals bearing these tumours. The results, which confirm those arrived at by observations on the nitrogen metabolism of tumour-bearing animals, show that the nitrogen percentage of rapidly growing tumours is smaller than that of the tissues of the host or that of the tissues of normal animals. This diminution in the nitrogen percentage was found to be due to the fact that, weight for weight, the cancerous tissue contains only about three-fourths of the amount of protein substances present in the tissues of the host. In other words, with the same amount of protein a bigger mass of tumour tissue than of host tissue can be built up. The simpler abiuret nitrogenous products of cell metabolism, however, are present in slightly greater amount in the cancerous tissue. It is pointed out that these results have a bearing on the mode of growth of cancerous tissue. Since the tissue of a neoplasm can be built up with less protein than the same weight of host tissue, the former must grow more rapidly than the latter in circumstances where both are using up nitrogenous material for mere growth at the same rate.—A. **Harden** and W. J. **Young**: The alcoholic ferment of yeast-juice. Part v., the function of phosphates in alcoholic fermentation. The two following equations were previously proposed by the authors to represent the course of alcoholic fermentation by yeast-juice:—

(1) $2C_6H_{12}O_6 + 2PO_4HR_2 = 2CO_2 + 2C_2H_6O + 2H_2O + C_6H_{10}O_4(PO_4R_2)_2$.

(2) $C_6H_{10}O_4(PO_4R_2)_2 + 2H_2O = C_6H_{12}O_6 + 2PO_4HR_2$.

These were founded on (*a*) the determination of the amount of carbon dioxide and alcohol produced by the addition of a known amount of phosphate in presence of excess of sugar; (*b*) the production of a hexosephosphate of the composition $C_6H_{10}O_4(PO_4R_2)_2$; (*c*) the occurrence of an enzymic hydrolysis of this substance with production of free phosphate. In order to obtain further experimental justification for this view, several additional determinations have been made, and these form the subject of the present communication. The results which have been obtained are as follows:—(1) When glucose or fructose is added to yeast-juice in presence of excess of phosphate, a period of accelerated fermentation occurs, during which the added sugar undergoes the reaction (1) quoted above, one molecule of carbon dioxide being evolved for each molecule of sugar added. (2) When the available phosphate of a mixture of ferment, coferment, and sugar is greatly reduced, the total fermentation produced becomes very small. The addition of a small amount of a phosphate to such a mixture produces a relatively large increase in the total fermentation, even after allowing for the amount of carbon dioxide equivalent to the phosphate added. (3) A hexosephosphate when digested with yeast-juice is hydrolysed by an enzyme (hexosephosphatase) with production of free phosphate, and a sugar, which is capable of being fermented by yeast. As the result of this hydrolytic action the hexosephosphates when treated with yeast-juice or zymin are finally converted into carbon dioxide, alcohol, and free phosphate. In the light of these results it becomes necessary, in discussing the chemical changes which the molecule of sugar may undergo in the process of fermentation, to take into consideration the fact that two molecules of sugar are involved in the reaction.

Zoological Society, February 15.—Dr. S. F. Harmer, F.R.S., vice-president, in the chair.—R. E. **Turner**: Additions to our knowledge of the fossorial wasps of Australia. Many new species were described, belonging chiefly to the families Thynnidæ and Ceropalidæ. The Thynnidæ had been collected chiefly by Mr. H. M. Giles in South-western Australia, and many interesting notes had been contributed by him on their habits. The sexual differences were extreme, and hitherto few Western Australian species had been correctly paired. The females were wingless, and the mouth-parts extremely minute, so that only liquid food could be taken, and this was usually disgorged by the male and placed in the mouth of the female. Mr. Giles had observed several cases of cross-pairing, in which the male was carrying the female of a different species; there could be no doubt as to the accuracy of this observation, though it was possible that the male claspers might be used for carrying the female when coupling did not take place. The geographical distribution of the genus Anthobosca (fam. Scoliidæ), now almost entirely confined to the Southern Hemisphere, was also discussed.—H. H. **Druce**: Descriptions of new Lycænidæ and Hesperiidæ from tropical South Africa. The paper contained an account of the numerous new forms collected by Mr. G. L. Bates on the Ja River, Cameroons, and by Herr Landbeck in the Upper Kasi district of the Congo.—C. L. **Boulenger**: Certain subcutaneous fat-bodies in toads of the genus Bufo. In *Bufo viridis*, of which the author had examined fresh material, these fat-bodies were very well developed, and on reflecting the skin from the ventral surface, one noticed a pair of gland-like fatty structures at the junction of the hind limbs with the trunk. They were present in both sexes, and varied considerably in size and colour in different individuals, but were quite constant in position.

Linnean Society, February 17.—Dr. D. H. Scott, F.R.S., president, in the chair, succeeded by Mr. H. W. Monckton, treasurer and vice-president.—W. T. **Saxton**: Recent investigations upon the anatomy of the genera Widdringtonia, Endl., and Callitris, Vent. Evidence is brought forward to show (1) that Widdringtonia and Callitris do not conform to the "Cupressineæ" type; (2) that Widdringtonia cannot be merged in the genus Callitris, but must rank as a distinct genus. Callitrineæ is suggested as a tribal name to include these two genera (possibly also Actinostrobus and Tetraclinis). Both morphological and anatomical differences are pointed out between Callitris and Widdringtonia, which seem more than sufficient to warrant the retention of Widdringtonia as a separate genus.—G. **Massee**: Evolution of parasitism in fungi. To understand clearly the evolution of parasitism it is important to grasp a fundamental point in the evolution of fungi generally. The most primitive forms were aquatic, and reproduced by zoospores, which necessitated the presence of water to secure their dispersion. As the fungi gradually took possession of dry land, a second asexual or conidia form of reproduction, suitable for dispersion by wind, &c., was gradually evolved. This supplementary conidial condition is always the form that has assumed a parasitic condition, the older sexual phase remaining as a saprophyte, and developing when the host is exhausted. Parasitism is mainly the outcome of opportunity, and the fact that fungi present all stages of parasitism, and that a saprophytic fungus can be educated to become a parasite, proves that parasitism is an acquired habit. Incipient or imperfectly evolved parasites promptly kill the host, and consequently curtail the period of their own existence, as *Pythium De Baryanum*. A higher stage of parasitism is reached by many of the rusts and smuts, *Ustilago avenae*, &c., where the host is attacked as a seedling, and is stimulated to an unusual condition of growth throughout its normal period of growth. More advanced parasites show a tendency to arrest the production of spores and conidia, and to perpetuate themselves by perennial mycelium located in some perennial vegetative portion of the host (root, tubers, &c.) or in the seed. In the most highly evolved parasites reproductive bodies are entirely arrested, and the parasite is perpetuated by hibernating mycelium only.—T. B. **Fletcher**: The Orneodidæ and Pterophoridæ of the Seychelles Expedition.—Dr. G. **Enderlein**: Die von Herrn Hugh Scott auf den Seychellen gesammelten Embiidinen, Coniopterygiden, und Hemerobiiden.—Dr. N. F. **Holmgren**: Die Termiten der Seychellen-Region.—L. A. **Borradaile**: The land and amphibious Decapoda of Aldabra.

Royal Anthropological Institute, February 22.—Sir Richard Martin, vice-president, in the chair.—Miss M. E. **Durham**: Notes on High Albania. High Albania is the only spot in Europe in which the tribal system exists intact. The tribes occupy the mountain land which forms the north-west corner of Turkey in Europe. They are exogamous, but male blood only counts. Each tribe is ruled by a council of elders, by ancient laws handed down by oral tradition, which are strictly enforced. Roughly, the tribes may be divided into three groups, one of which tells a tale of origin from Bosnia, the second of partial origin from Rashia, and the third, which declares that it has "been there all the time." The tale of origin from Bosnia is confirmed by the fact that the same tattoo patterns used by these tribes are used in certain districts of Bosnia. They consist of various arrangements of the cross, the sun, and the moon. Among other very ancient customs, the Levirate is still practised, even by many of the Roman Catholic tribes. Blood vengeance is extremely prevalent throughout both Christian and Moslem tribes. Its rules are complicated. It is undertaken rather to cleanse the honour of the slayer than to inflict punishment on the slain. Up country the houses are all stone kulas (towers), built for defence, and having no windows, but only loop-holes for rifles. Communal families of as many as forty members live together in one room, ruled by the house lord, who has often power of life and death over his subjects. Marriage is always by purchase, save for an occasional forcible capture. Children are betrothed in infancy. Thirteen to fifteen is a common age for a girl's marriage, and fifteen to eighteen for a boy. Hospitality is the universal law of the mountain. The tribesman, if he receives a traveller at all, gives him of his best.

PARIS.

Academy of Sciences, February 21.—M. Émile Picard in the chair.—G. **Humbert**: The minima of the classes of binary and positive quadratic forms.—Armand **Gautier**: The differential characters of waters arising from springs of superficial or meteoric origin and of waters of central or igneous origin. In opposition to the accepted views of Daubrée, the author regards many mineral waters as virgin springs, not arising from infiltrated water, but issuing for the first time from the earth. Somewhat similar views have been advanced by Suess. These virgin waters are characterised by their issuing from eruptive faults or in relation with metallic lodes, by being independent of the seasons and meteorological phenomena, by the constancy of their composition and temperature throughout the year, and by the presence of certain elements such as fluorine, boron, arsenic, iodine, &c., and by the absence of the carbonates of the alkaline earths.—Gabriel **Kœnigs**: The conjugated curves in the most general relative movement of two solid bodies.—H. C. **Saint-René**: A solution of a problem of vision at a distance.—Percival **Lowell**: New canals on the planet Mars. Two large canals east of Syrtis Major were observed at the Flagstaff Observatory on September 30, and reasons are given for supposing that these canals are really new on Mars. They have the character of the other canals—a uniform line of geometrical appearance.—Charles **Nordmann**: The intrinsic brightness of the sun. The effective temperature of the solar photosphere is estimated at 6450° C. absolute. The intrinsic brightness of the sun is calculated to be 319,000 decimal candles per square centimetre.—M. **Coggia**: Observations of the comet 1910*a*, made at the Observatory of Marseilles with the Eichens equatorial of 26-cm. aperture. Positions are given for February 4, 5, 7, 8, 9, 10, and 11.—W. **Stekloff**: A general theorem of existence of fundamental functions corresponding to a linear differential equation of the second order.—D. **Pompéiu**: The singularities of uniform analytical functions.—Jean **Chazy**: Differential equations the general integral of which possesses an essentially mobile break.—G. **Cotty**: The transformation of Abelian functions.—Marcel **Brillouin**: Concerning functions determined by their value on a part of the boundary and that of their differential coefficient normal to the remainder of the boundary.—A. C. **Vournasos**: The reaction of nascent hydrogen in the dry state. By heating sodium formate, with or without the addition of sodium hydroxide, hydrogen is evolved. If phosphorus, sulphur, or arsenic is added to this mixture, and the whole heated to about 400° C., the corresponding hydrogen compounds of these substances are obtained. With sulphur, the pure dry sulphuretted hydrogen prepared in this way is suitable for use in analysis.—H. **Baubigny**: The separation and purification of the dithionates produced in the decomposition of silver sulphite or its double salts.—H. **Gaudechon**: The bromine derivatives of dimercurammonium.—V. **Auger**: The alkaline mangani-manganates. These compounds arise from the action of permanganates upon moist caustic soda, slowly in the cold, rapidly on warming, with loss of oxygen. The sodium salt has the composition

$$Mn_2O_3.5Na_2O.8H_2O.$$

—Léo **Vignon**: Textiles and insoluble colouring matters.—H. **Copaux**: The inequality of the properties of the two forms (right and left) of potassium silicotungstate, and, in general, of crystals possessing rotatory power. The salt isolated by Wyrouboff was dextrorotatory only. The author has accidentally obtained a lævorotatory variety, and has been able to show that these two forms differ greatly in stability, the lævo variety passing over completely into the dextro form on re-crystallising from water. The two species differ considerably in their solubility.—J. **Wolff**: The action of the alkaline dibasic phosphates on tyrosinase. A reply to some remarks of M. Agulhon. Experiments are cited in detail showing that the action of the enzyme is much assisted by the presence of sodium phosphate, although at the commencement the phosphate retards the reaction.—M. **Billon-Daguerre**: The sterilisation of liquids by radiations of very short wave-length. The invisible region of the spectrum, with wave-lengths between 1030 and 1100 Ångström units, is the seat of radiations possessing a chemical action about twenty-five times greater than the ultra-violet rays produced by mercury vapour lamps. The apparatus described utilises these very short radiations; details are given of its sterilising activity, and a domestic installation is figured possessing advantages economically over the mercury vapour lamp steriliser.—Paul **Hallez**: The protection encystment of *Prostoma lumbricoideum*.—H. **Vincent**: The active immunisation of man against typhoid fever. A new antityphoid vaccine.—F. **Kerforne**: The pre-Hercynian movements of the Breton massif.—M. de Montessus **de Ballore**: The barograph considered as a recording seismoscope. Records on barographs have frequently been found to show disturbances corresponding to earthquake shocks. From the examination of four years' barograms taken at Santiago, it is concluded that the barograph cannot be regarded as a useful seismoscope.—F. **Dienert**: The estimation of fluorescent substances in the control of the sterilisation of water.

DIARY OF SOCIETIES.

THURSDAY, MARCH 3.

ROYAL SOCIETY, at 4.30.—The Depression of Freezing Point in very Dilute Aqueous Solutions: T. G. Bedford.—Sturm-Liouville Series of Normal Functions in the Theory of Integral Equations: J. Mercer.—The Solubility of Xenon, Krypton, Argon, Neon, and Helium in Water: A. von Antropoff.—Measurements of the Absolute Indices of Refraction in Strained Glass: Dr. L. N. G. Filon.

ROYAL INSTITUTION, at 3.—Illumination, Natural and Artificial (Experimentally Illustrated): Prof. S. P. Thompson, F.R.S.

RÖNTGEN SOCIETY, at 8.15.—Dental X-ray Technique: C. A. Clark.

LINNEAN SOCIETY, at 8.—Our British Nesting Terns: W. Bickerton.

FRIDAY, MARCH 4.

ROYAL INSTITUTION, at 9.—Magnetic Storms: Dr. C. Chree, F.R.S.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Reinforced Concrete as applied to Retaining-walls, Reservoirs, and Dams: A. J. Hart.

GEOLOGISTS' ASSOCIATION, at 8.—On a Fuller's Earth Section at Combe Hay, near Bath: L. Richardson.—Some Notes on the Superficial Geology and Physical Features of Epping Forest: S. Hazzledine Warren.

SATURDAY, MARCH 5.

ROYAL INSTITUTION, at 3.—Electric Waves and the Electromagnetic Theory of Light: Sir J. J. Thomson, F.R.S.

ESSEX FIELD CLUB (at the Essex Museum, Stratford, Essex), at 6.—Some Notes on the Cricket-bat Willow (*Salix alba*, var. *coerulea*) in Essex: Miller Christy.—Report on the Lichens of Epping Forest (first paper), together with some General Remarks on the Group: R. Paulson and P. G. Thompson.

MONDAY, MARCH 7.

ARISTOTELIAN SOCIETY, at 8.—The Reality of Individua: Miss H. D. Oakeley.

ROYAL GEOGRAPHICAL SOCIETY, at 8.30.—Land and People in the Kasai Basin of the Congo: E. Torday.

ROYAL SOCIETY OF ARTS, at 8.—Lead Work: L. Weaver.

SOCIETY OF CHEMICAL INDUSTRY, at 8.—The Rational Analysis of Clays: W. C. Hancock.—On the Application of Pressure Gas to Furnace Use: A. W. Onslow.—A New Gas Sampling Tube: G. Nevill Huntly.—The Complete Analysis of Leather, and a Common Mistake in the Determination of the Degree of Tannage: Dr. J. Gordon Parker and M. Paul.—The Spontaneous Decomposition of Blasting Gelatine: J. B. Henderson.

SOCIETY OF ENGINEERS, at 7.30.—Sewage Disposal Ideals: W. C. Easdale.

VICTORIA INSTITUTE, at 4.30.—Assur and Nineveh: Dr. T. G. Pinches.

TUESDAY, MARCH 8.

ROYAL INSTITUTION, at 3.—The Emotions and their Expression: Prof. F. W. Mott, F.R.S.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—Exhibition of the Gibraltar Skull, with Lantern Demonstration of Certain Features Characteristic of Palæolithic Man: Dr. A. Keith.

INSTITUTION OF CIVIL ENGINEERS, at 8.—Birmingham Sewage-disposal Works: J. D. Watson.—Salisbury Drainage: W. J. E. Binnie.

WEDNESDAY, MARCH 9.

GEOLOGICAL SOCIETY, at 8.—The Carboniferous Succession in Gower (Glamorganshire): E. E. L. Dixon and A. Vaughan.

ROYAL SOCIETY OF ARTS, at 8.—The Public Trustee and his Work: C. J. Stewart.

THURSDAY, MARCH 10.

ROYAL SOCIETY, at 4.30.—*Probable Papers*: The Causes of the Absorption of Oxygen by the Lungs (Preliminary Communication): C. Gordon Douglas and Dr. J. S. Haldane, F.R.S.—The Action of Nicotine and other Pyridine Bases upon Muscle: Dr. V. H. Veley, F.R.S., and Dr. A. D. Waller, F.R.S.—The Extinction of Sound in a Viscous Atmosphere by Small Obstacles of Cylindrical and Spherical Form: C. J. T. Sewell.—The Ionisation of Various Gases by the Rays of Actinium: Dr. R. D. Kleeman.

MATHEMATICAL SOCIETY, at 5.30.—Forms for the Remainder in the Euler-Maclaurin Sum-formula: W. F. Sheppard.—The Scattering of Light by a Large Conducting Sphere: J. W. Nicholson.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Short Circuiting of Large Electric Generators and the Resulting Forces on Armature Windings; The Design of Turbo Field Magnets for A. C. Generators with Special Reference to Large Units at High Speeds: Miles Walker.

ROYAL SOCIETY OF ARTS, at 4.30.—Indian State Forestry: Saint-Hill Eardley-Wilmot.

FRIDAY, MARCH 11.

ROYAL INSTITUTION, at 9.—Ionisation of Gases and Chemical Change: Dr. H. Brereton Baker, F.R.S.

PHYSICAL SOCIETY, at 8.—On Coherers: Dr. W. H. Eccles.—Earth-air Electric Currents: Dr. G. C. Simpson.—An Automatic Toepler Pump designed to Collect the Gas from the Apparatus being Exhausted: Dr. B. D. Steele.

MALACOLOGICAL SOCIETY, at 8.—Pleistocene, Holocene, and Recent Non-marine Mollusca from Mallorca. Marine Shells from Alcudia, Mallorca: Rev. R. Ashington Bullen.—Classification of the Gastropoda: R. J. Lechmere Guppy.—On the Occurrence in England of *Valvata macrostoma*, Steen: A. S. Kennard and A. W. Stelfox.—Description of a New Species of Helicodonta from Spain: G. K. Gude.

SATURDAY, MARCH 12.

ROYAL INSTITUTION, at 3.—Electric Waves and the Electromagnetic Theory of Light: Sir J. J. Thomson, F.R.S.

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