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The Influenza Problem.

THE widespread recrudescence of influenza in this country, although on a less fatal scale and of a less virulent type than in the experience of 1918–19, is an unpleasant reminder of our present helplessness in respect of this disease. Many volumes have been written about it. The old Local Government Board issued two reports by Dr. Franklin Parsons, which summarised all we then knew of the epidemic of 1890, and did much to expand our knowledge; and we have now before us an even more portly tome of nearly 600 pages upon the subject, issued by the new Ministry of Health. This report contains valuable historic material, an admirable clinical study of the disease, and suggestive speculations on the statistical aspects of the problem presented by it. These forcibly impress us with the imperfections of statistics dealing with altogether imperfect material. But we cannot be said to have greater knowledge of the disease, from the point of view of preventive medicine, than when Dr. Parsons's reports were issued. This is no reflection on the Ministry of Health; for in every civilised country investigators have similarly drawn a blank so far as guidance for the prevention of the disease is concerned.

We know certain elementary facts which, if they could be universally applied in practice, would prevent influenza from spreading; for the disease is infectious, and it is practicable to lessen the public opportunities of infection by avoiding unnecessary assemblies of people. But how can we avoid infection in social and business life, in view of the early infectivity of the disease, the failure to recognise mild attacks, and the short incubation period, which multiplies centres of infection at a very rapid rate? We commonly fail to prevent the spread of ordinary catarrhs; and this is an index of our incapacity or inertia in relation to the more serious disease.

The mere enumeration of matters concerned with influenza on which we are still ignorant is an almost tedious task. Let us attempt it partially. We know that at uncertain intervals influenza marches, or rather flies, through the world, without any known reason. The epidemics in this country of 1803, 1833, 1837–8, and of 1889–92, are well known, but many occurred in previous centuries, and some have even asserted that the sweating sickness was a type of influenza. We know that when influenza becomes epidemic it tends to recur in secondary and tertiary waves, as in our recent experience. The present outbreak is the fourth since 1918. Dr. Brownlee has given interesting evidence pointing to an appearance of law in the intervals after which recurrences occur; and we may hope to hear more from him on this point, not only as regards this country but also for other countries, as to whether this law holds good internationally.

Knowledge of the natural history of these outbreaks may be expected eventually to give some clue to prevention, though this is not yet visible. But it is not known why influenza takes on a world-wide march at irregular intervals. We may assume that endemic influenzal infection of low virulence and infectivity, for some unknown reason, changes its biological characters, and that one or both of these characteristics may become enhanced; but why? Attempts to associate pandemics with special meteorological conditions have had little or no success; and we are little further advanced than when Sydenham appealed to the "epidemic constitution" of certain years.

As an alternative to the acquirement of enhanced biological properties by the contagion of influenza may be cited the evidence of importation of infection and the rapid spread of the disease from country to country; but this merely puts the practical difficulty further back. Why this exceptional spread from country to country, and why does not influenza prevail, like measles, every second year in a given urban community?

Further light would be more easily obtainable if we were certain that the Pfeiffer bacillus is the true causal agent of influenza; it is not dispossessed from this position, but the evidence of bacteriologists in recent outbreaks has not strengthened its position; and although bacteriologists have isolated the

bacillus from secretions of influenzal patients and grown it in separate culture, they have failed in the crucial test of inoculation in animals to reproduce influenza.

This brings us to our next difficulty. In the absence of a certain bacteriological test, a further obstacle is that there is no characteristic symptom in influenza, like the rash in scarlet fever, or the throat membrane in diphtheria. On the contrary, what is supposed to be influenza assumes several types. At present cases with gastric symptoms are common, with few or no respiratory complications in a proportion of cases. But are we certain that these two types are the same disease? There is much evidence that commonly there is mixed infection; and in the great epidemic of 1918–19, which destroyed more of mankind than the great war, much of the mortality was due to secondary (or primary) invasion of hæmolytic streptococci.

On such an apparently simple point as the immunity conferred by a single attack the evidence is discrepant. Although it did appear that many of those attacked in the summer epidemic of 1918 escaped attack in the terrible epidemic of the following winter, the evidence is not satisfactory. It appears clear that if immunity is conferred by an attack, the immunity is of short duration; and this brings out the further point that inoculation of a vaccine prepared from the Pfeiffer bacillus and the associated coccal organisms cannot be expected to do much good, except perhaps in diminishing the seriousness of pulmonary complications.

Nor have we any plausible explanation of the remarkable change in the age incidence of deaths from influenza. In the epidemic of 1889–92 some 60 to 70 per cent. of all the recorded deaths from influenza occurred among patients more than 55 years old; in the recent epidemic, fatal cases at these ages formed only some 12 per cent. of the total, while about 70 per cent. of the total deaths were of patients less than 35 years old. Does this imply that we have recently been concerned with a different infection, or what is the explanation?

It is noteworthy that coincidently with epidemic influenza, certain other diseases, like cerebro-spinal meningitis and encephalitis lethargica, have prevailed to an exceptional extent. This has been explained by Dr. Hamer and others as implying that we are, in fact, in the grip of a single infection assuming multiform manifestations. But the association was not evident in the 1889–92 epidemic; and it is equally open to us to assume—and there are good grounds for maintaining—that all these diseases, each specific in character, are favoured by the same "epidemic constitution"—or what is concealed under this designation—and that they are not identical diseases.

The preceding incomplete review of the chief of the unknown factors in influenza must necessarily be somewhat depressing. It is well, therefore, to look for a moment at other diseases which, like influenza, at irregular intervals and for unknown reasons, assume world-wide movements, invading mankind in many countries. Among these cholera, plague, and smallpox may be specially mentioned. Yet each of these is entirely controllable, and, so far as a large part of the world is concerned, has been controlled. Cholera is now kept within bounds and almost non-existent in every country with elementary sanitation. Plague is controllable to the extent to which infection by rats and their fleas is stopped: a practicable programme. In smallpox there is the important additional protection of vaccination, and against a population protected by this measure waves of smallpox infection break for ever impotently. The last-named illustration is significant from the point of view of influenza. Both infections are usually received by the respiratory tract. Against one vaccination affords protection, against the other results of inoculation have been more than dubious. The world is waiting for further light. How is influenza and how are respiratory infections in general to be prevented? This is the unconquered region of preventive medicine. It will doubtless be occupied eventually, but after how much delay and on what plan it would be rash to hazard a prophecy.

An Elusive Group of Marine Organisms.

The Free-living Unarmored Dinoflagellata. By C. A. Kofoid and Olive Swezy. (Memoirs of the University of California, Vol. 5.) Pp. viii + 562 + 12 plates. (Berkeley, California: University of California Press, 1921.)

THE University of California at Berkeley, Cal., supported no doubt by large revenues from the State, sets a noble example in publishing valuable contributions to knowledge. In addition to about thirty octavo series in zoology, physiology, and other sciences, the University Press issues large quarto Memoirs, of which the fifth volume is Kofoid and Swezy's "Dinoflagellata," a very notable work of 570 pages and twelve coloured plates. It is the result of observations made by Prof. Kofoid and his pupils over a series of years from 1901 onwards at the marine laboratories of the University of California and the more recently established Scripps Institution for Bio-

logical Research at La Jolla—both by work at sea off the coast of Southern California and by investigation of the beach sands.

The Dinoflagellata form an exceedingly important source of the food supply of the sea both in numbers and in the total mass produced. As synthetic producers of carbohydrates, proteids, and fats they hold high rank amongst microscopic marine organisms, and in abundance they are second only to the diatoms in the plankton, while locally and on occasions they may far outnumber them. These local massive developments are the all but universal cause of the discoloured seas and of the phenomena of luminescence. The present monograph deals with the least-known and most elusive members of the group, the naked or unarmoured forms.

One great difficulty in their investigation is the extreme delicacy of these organisms and their tendency to undergo cytolysis in even a few moments' exposure to light under the microscope. They are unfortunately most sensitive to the action of fixing re-agents, and almost instantaneous distortion and disruption prevent the preservation of permanent preparations. The investigator is therefore limited to rapid and immediate observation of the freshly captured living and usually very active organisms. It is only on a coast such as that of Southern California, where pure oceanic water with a rich pelagic fauna is brought within a few miles of a laboratory equipped like the Scripps Institution, that work such as that of Prof. Kofoid could be carried on. A specially devised net of the finest silk is towed for a very short time at a depth of 80 metres, the catch transferred to a relatively large volume of water, rushed ashore in a fast motor-boat (30 miles an hour), and divided up at once for the microscopes of half-a-dozen assistant observers, a surprising number of new and remarkable forms in exceptionally fine condition being revealed. Ordinary methods of plankton collection and preservation yield no traces of these extremely delicate organisms. This is an excellent example of new and refined methods at sea, such as can be adopted only in connection with a biological station, which are giving new results of great scientific interest. It must not be supposed, however, that all these Dinoflagellates are confined to oceanic water. Some are neritic, and species of Amphidinium, for example, have been found in vast numbers on damp beach sand at several localities in England, California, and elsewhere.

Many of these new unarmoured Dinoflagellates are brilliantly coloured, as the beautiful plates abundantly show, and some are wonderfully organised and specialised for such minute protozoa. Some possess, amongst other "organelles," a complicated ocellus or "eye," with lens, pigment mass, and sensory core, as well as a large mobile tentacle, and groups of nematocysts resembling those of Cœlenterata. The whole group and its subdivisions and the numerous genera, sub-genera, and species are discussed most fully from every point of view—general morphology and relations, minute structure, physiology, history, and distribution. In their nutrition the majority of marine unarmoured Dinoflagellates are holozoic, and even some of those that contain chromatophores and were hitherto supposed to be holophytic are now found to contain ingested foreign bodies in the cytoplasm. What is known of the life-cycles, including encystment, spore formation, binary and multiple fission, and possibly conjugation—and the effects of parasitism in some forms—are all discussed, but it is evident that much has still to be discovered in regard to these matters.

In regard to the evolution of the group, our authors show that it probably arose from the Cryptomonads, and the Dinoflagellata of to-day represent the terminal twigs of a phylogenetic branching. The attempt to find ciliate affinities through the remarkable genus Polykrikos is rejected as a misinterpretation. A new form, Protodinifer, is regarded as bridging the gap between the two main groups of Dinoflagellates, the Diniferidea and the Adiniferidea, but it may be pointed out that "Protodinifer" is clearly identical with the *Pelagorhynchus marinus* of Pavillard (*Comptes rendus*, January, 1917). Amongst notable changes in the more familiar classifications of the text-books are the removal of Noctiluca from the Cystoflagellata and its inclusion in the Gymnodinoidæ, and the abolition of the Pyrocystaceæ of Murray, Apstein, West, and others, as these latter organisms are now to be regarded as merely phases in the life-history of other Dinoflagellates.

In addition to the nematocysts in Nematodinium and Polykrikos and the ocellus in Pouchetia, etc., the most remarkable further specialisation is seen in the highly developed appendage or "prod," with protractile and retractile fibrillæ, which reaches its climax in the genus Erythropsis. The authors, in pointing out the cœlenterate resemblances of the nematocysts and the tentacle placed on the edge of the sulcus or mouth, and also the tendency to a multicellular condition seen in the "chains" of Ceratium and the two-, four-, or eight-celled "somatella" of Polykrikos, suggest that "pelagic Dinoflagellata may have given rise

to simple pelagic Cœlenterates in which cell boundaries and cell layers may have played only a secondary and belated part as the size of the organism increased."

The economic importance of these organisms is great, both as a food supply and also occasionally as a destructive agency. It is well known that they form a large percentage of the stomach contents of sardines and other small fish. At times they are the dominant forms of the plankton, and have been recorded by Kofoid as the cause of outbreaks of "red water" on the Californian coast and elsewhere which may be a menace to the health and life of slow-moving or bottom-living animals which, being unable to escape from the infested area, die in quantity and are cast up in masses on the shore. Such discoloration of the water, due to species of Gymnodinium and Gonyaulax, are recorded as extending sometimes (August, 1917) for a hundred miles or more along the coast.

To point out a few slips in such a splendid memoir may seem ungracious, but Prof. Kofoid would probably prefer to have friendly criticism: In the phylogenetic diagram on p. 84, have not Protodinifer and Oxyrrhis exchanged places, should not Protodinifer be Pelagorhynchus, and, near the top of the diagram, should not Nematopsis be Nematodinium? The text-figure on p. 509 is evidently printed upside down, and in Fig. F (p. 30) the numbers 2, 3, and 4 are misplaced. Some of the references to figures in the text are not correct, but the careful reader will notice these for himself and will readily discover what is intended.

So many species are described, redescribed, or discussed, and the synonymy and history are given so fully, that the memoir is truly a monograph of the group, and will be found indispensable by all who work at these important lower organisms.

W. A. HERDMAN.

The Theory of Probability.

A Treatise on Probability. By J. M. Keynes. Pp. xi+466. (London: Macmillan and Co., Ltd., 1921.) 18*s*. net.

DR. KEYNES'S book is a searching analysis of the fundamental principles of the theory of probability and of the particular judgments involved in its application to concrete problems. He adopts the view that knowledge may be relevant to our rational belief of a proposition without amounting to complete proof or disproof of it, and treats the probability as a measure of this relevance. Otherwise he does not attempt to define "probability," regarding it as a concept intelligible without further definition. In this respect, as in several others, he is in agreement with the views expressed by Dr. Wrinch and the present reviewer (*Philosophical Magazine*, vol. 38, 1919, pp. 715–31), and some comparison of the two presentations may not be out of place.

Previous writers have practically all assumed that probabilities can be expressed by numbers, and this assumption was put into precise form in the paper mentioned. Dr. Keynes departs completely from tradition on this point. Defining an "argument" as the process of passing to knowledge about one proposition by contemplation of it in relation to another of which we have knowledge, he denies not only that the probabilities of all arguments can be expressed by numbers, but also that they can be arranged in a one-dimensional series at all. Thus the probability of one argument may be neither greater than, equal to, nor less than that of another. The difference in actual application between this theory and ours appears likely to be slight, for the definitions and hypotheses are such that practically any two probabilities that one needs to compare are comparable. From these the formal theory is soundly developed.

The principle of non-sufficient reason, or indifference, asserts that we assign equal probabilities to propositions if we have no reason to do the contrary. The author criticises severely many previous applications of this principle (so severely that an unprepared reader is likely to be betrayed into expecting him to reject the principle altogether). He finally modifies it by saying that neither of the propositions deemed equally probable may be expressible as the disjunction of two mutually inconsistent propositions, of the same form as itself, and both consistent with the data. His precise statement of this important principle makes it possible to evaluate a large class of probabilities that could otherwise be only estimated, and is a most useful advance.

Dr. Keynes rejects definitely the view of Jevons and others that if any two alternatives are exhaustive and mutually exclusive, and we have no reason to prefer one to the other, the probability of each is $\frac{1}{2}$. His reasons for believing that this view leads to contradictions, however, appear incorrect. He says on p. 43: "If, for instance, having no evidence relevant to the colour of this book, we could conclude that $\frac{1}{2}$ is the probability of 'This book is red,' we could conclude equally that the probability of each of the propositions, 'This book is black' and 'This book is blue,' is also $\frac{1}{2}$. So that we

are faced with the impossible case of *three* exclusive alternatives all as likely as not." It appears to us that each of these estimates is based on different evidence, and, therefore, that it is quite possible that the sum of the probabilities should be greater than unity. A person who could recognise only one colour, say, blue, all others appearing alike to him, would estimate the probability that the book is blue at $\frac{1}{2}$. A person who could recognise only red would make a similar estimate for red. But one who could distinguish red, blue, and black, and no others, would estimate each as having a probability of $\frac{1}{3}$. In each case we follow the author in assuming no previous knowledge of the proportions of different colours among books.

The point is worth insisting upon, for we believe that the author has for such reasons refrained from estimating prior probabilities in many cases where such estimates would have been useful. In his discussion of sampling inference, for instance, he refuses to admit that any plausible estimate of the probable composition of a sample can be made, however large a sample has already been examined, unless we have further evidence that no disturbing cause exists. Admittedly the inference depends on the prior probabilities of different compositions, but we have shown that in ordinary cases a wide range of variation of the prior probability produces little variation in the inference made with regard to the composition of a large sample, and we think this is the only justification required. The acquirement of knowledge about a disturbing cause provides additional data and is valuable for that reason; its absence is no reason for denying a probability inference not based on it.

The author's insistence on the desirability of careful testing of the sample to see whether different subclasses from it have compositions similar to the whole is, however, very important on other grounds, for his careful discussion indicates the precise usefulness of a kind of additional information that is often obtainable and valuable. His conclusion (p. 426) that "sensible investigators only employ the correlation coefficient to test or confirm conclusions at which they have arrived on other grounds" is an exaggerated statement, but perhaps a salutary one.

A form of the frequency definition is discussed and rejected on the ground that it does not give any basis for induction. According to this the probability of a proposition p on evidence q is to be obtained by selecting a large number n of instances of q. If m of these are also instances of p, the probability of p given q is defined to be m/n. This theory is taken too seriously; it would be sufficient objection to point out that, unless m/n is 0 or 1, the probability would necessarily be changed by having $n+1$ instances instead of n, and would therefore be conventional. In the form of the frequency theory discussed (and also rejected) in our paper the probability is defined as the *limit* of this ratio when n tends to infinity. This view, though it has been seriously advocated, is not mentioned by the author.

The faults attributed to the book above are all on the side of excessive caution, and the positive contributions are extremely valuable. It is clearly written, with a good index and a copious bibliography. The misprints are few. Whitehead and Russell's "Principia Mathematica" is, however, mentioned a few times as if it were by a single writer. The work should be read by every student of science who aims at a real understanding of his subject.

HAROLD JEFFREYS.

The Royal Society Catalogue.

Catalogue of Scientific Papers, Fourth Series (1884–1900). Compiled by the Royal Society of London. Vol. 17, *Marc–P*. Pp. v+1053. (Cambridge: At the University Press, 1921.) 9*l*. net.

THE high standard set by the volumes already published in this series is fully maintained in the seventeenth volume of the Royal Society's "Catalogue of Scientific Papers." The work of preparing the material for the press and of proof-reading was carried out by Miss Vagner and Miss Barnard, and until December 1920 Miss Chapman was also engaged upon the work. The Cambridge University Press is to be congratulated on the typographical excellence of the volume, the small type which had to be used being quite easy to read.

The papers indexed are those published during the seventeen years 1884 to 1900 by authors whose names begin with the four letters M (from Marc onwards), N, O, and P. No less than 10,662 names are indexed, the number of separate papers being 57,474. Thus, on an average, each author has published one paper every three years. The volume brings up the total number of authors' names already printed for the period 1884–1900 to 49,750, and the total number of entries of papers published by authors whose names begin with letters from A to P inclusive to 279,902. The catalogue of papers by authors whose names begin with letters from Q to Z is still to be published.

The Committee say that the difficulties in the printing and publishing trade, which for a time delayed the regular delivery of proofs, have now been overcome, so that they look forward with

confidence to an early completion of the remaining volumes. When these are published the gap between the "Catalogue of Scientific Papers" and the "International Catalogue of Scientific Literature" will be filled so far as the index of authors' names is concerned; the indexing of scientific papers under authors' names will then be complete up to 1914.

There will still remain the subject-index, of which we believe only the volumes for mathematics, mechanics, and physics have been published, and that some fourteen volumes have yet to appear. To most of us a subject-index is much more useful than an author-index. While an author-index is essential as a permanent record of work done by individual authors, it will be of little use to an investigator anxious to discover what has previously been done in a particular line of research. For such a purpose a subject-index is required. We therefore hope that the Royal Society will proceed with the production of subject-indexes for the period 1800–1900 on the plan already begun with such success.

In addition to the surname of the author, the "Catalogue of Scientific Papers" gives the full Christian names so far as these can be ascertained. This is not merely in order to give credit to those to whom it is due, but also to make it easy for those who refer to the catalogue to distinguish between an acknowledged master of a subject and a little-known author who may chance to have the same surname. We commend the printing of titles in the original language, followed, when necessary, by an English translation. Those who have attempted to render a foreign language into English know how difficult it is to convey the exact meaning of the author; it is better, therefore, to let him speak for himself. In some of our abstracting journals we may find titles of foreign papers not only translated but so altered that no one could reconstruct the original. Nevertheless we think the compilers of this volume would have done well to add the English equivalent of some of the titles which they have printed without a translation. This would apply, for example, to many papers published in Swedish.

The Royal Society, representing, as it does, all branches of science, is clearly the body best able to carry to a successful issue any work indexing the whole field of science; all who take an interest in science will therefore feel that they owe the Society a debt of gratitude for having undertaken the great work of making a complete catalogue of the scientific papers published during 1800–1900 and for showing its intention to continue the work to a successful issue. A monumental work of this kind will never be out of date, but will be treasured as a permanent record of the marvellous achievements in the domain of science during the nineteenth century.

Our Bookshelf.

Handbuch der biologischen Arbeitsmethoden. Edited by Prof. Dr. Emil Abderhalden. Abt. 5, *Methoden zum Studium der Funktionen der einzelnen Organe des tierischen Organismus.* (1) Teil 3, Heft 1, *Entwicklungsmechanik.* Pp. 218. 66 marks. (2) Teil 3, Heft 2, *Entwicklungsmechanik.* Pp. 219–440. 72 marks. Abt. 9, *Methoden zur Erforschung der Leistungen des tierischen Organismus.* (3) Teil 1, Heft 1, Lieferung 34, *Allgemeine Methoden.* Pp. 96. 30 marks. (Berlin und Wien: Urban und Schwarzenberg, 1921.)

(1) THE five articles which form this "Heft" are concerned with the technique of experimental embryology. In his account of micro-surgery Prof. Spemann deals with the operations for the examination of eggs—for dividing them either incompletely, *e.g.* by means of a looped hair, or by actually cutting the egg into two—with transplantation of parts of embryos to unusual positions, etc. Prof. Barfurth discusses the technique for the inquiry into heteromorphosis and regeneration in various groups of animals—embryos as well as adults. In this part Fig. 48 is printed without reference letters or description. Prof. H. Przibram gives methods for investigating the influence on development of heat, light, gravity, etc.; Dr. Karl Herbst deals with the methods of modifying development by means of various salts in solution, and Dr. Neumayer describes the instruments and technique of a number of operations. The work forms a useful source of reference for research workers and advanced students who desire to ascertain the methods which have been most successful in practice.

(2) The memoir by Prof. Rhumbler deals with the methods of imitating or producing "models" of living processes by physical devices—*e.g.* amœboid movement, the ingestion of food as by an amœba, the formation of a test as in the Rhizopoda, cell-division, fertilisation, etc. The volume is a helpful and concise contribution to the literature of the physics of vital phenomena.

Both these parts would have been improved if they had been provided with an index or a table of contents.

(3) In this, the first article of a new volume, Prof. Przibram gives many useful suggestions as to the methodical beginning and carrying through of research in experimental zoology. The selection and clear statement of the problem to be attacked, the economical use of living specimens —and also of time—by carrying out, wherever possible, more than one line of research on the same

material, care in labelling all specimens—on these and other cognate matters the author draws from his extensive experience, and the article is one in which those who are beginning research will find much that is helpful.

Municipal Engineering. By H. Percy Boulnois. (Pitman's Technical Primers.) Pp. vii + 103. (London: Sir Isaac Pitman and Sons, Ltd., 1921.) 2*s.* 6*d.* net.

IT is clear from the matter in this little book that the author has had very extensive experience in municipal engineering, and the list of important appointments he has held—as noted on the title-page—gives ample confirmation of this impression. He is therefore usually a safe guide in the matter of offering advice to young men who intend to enter this profession. The position, appointment, and training of the municipal engineer are explained, and the special responsibilities he has to accept are fully discussed. A considerable number of examinations have to be passed; these provide, or should provide, evidence of a sound training in the scientific and other subjects required of the municipal engineer. It is, therefore, unfortunate that the author, whilst decrying "cramming," suggests on p. 44 that there are numerous coaches or crammers who can assist a candidate. We should rather have expected advice of a kind which would have led young men to spend a few years in following a course in engineering with special attention to municipal engineering. Such courses are now available at several colleges, and when combined with a pupilage for the sake of acquiring practical experience will produce properly qualified men. That the author fully understands this is clear from other pages in the book, and it is unfortunate that the blemish on p. 44 should appear in this otherwise excellent and helpful volume.

History of the Great War, based on Official Documents. By Direction of the Historical Section of the Committee of Imperial Defence: Naval Operations. By Sir J. S. Corbett. Vol. 2. Pp. xi + 448 + 17 plans. (London: Longmans, Green, and Co., 1921.) 21*s.* net.

THIS volume, the second of Sir Julian Corbett's masterly series on the naval operations of the great war, covers the six months from November, 1914, to May, 1915. It is based primarily on the official documents of the British Admiralty, but the information supplied by these has been supplemented from other sources, notably the revelations of disillusioned German seamen, such as Admiral Scheer and Admiral Hugo von Pohl. The narrative is fascinating in its interest. It displays in their entirety the operations of which at the time of their happening we obtained but partial glimpses. Here we can read—and, if we once start, must continue to read—about the raid on Scarborough and Hartlepool (December, 1914), the loss of the *Formidable* (January, 1915), the early attacks on the Dardanelles (February, 1915), and the sinking of the *Lusitania* (May, 1915). The maps and plans are numerous and excellent.

A Sketch-map Geography: A Text-book of World and Regional Geography for the Middle and Upper School. By E. G. R. Taylor. Pp. viii + 147. (London: Methuen and Co., Ltd., 1921.) 5*s.*

A SERIES of sketch-maps presenting the fundamental geographical facts of regions and places, with brief explanatory text. The author claims three advantages for this method. In his first claim, that pupils will acquire the habit of working out the geography of a place for themselves, instead of reading up the facts, we think that he is over-sanguine. Boys, at any rate, will just learn up his sketch-maps by heart as they formerly did the written facts. Probably, however (as he claims next), they will remember these facts better, and will find the diagrams more interesting than solid paragraphs. Also the third advantage may be realised—the pupils will become accustomed to illustrate their work with sketch-maps, and this is an excellent habit.

The book is in itself too "sketchy" for a youthful student. It is meant to be used in conjunction with a good atlas, but should also be supplemented by a more detailed text-book. It may then be a valuable aid to teachers.

Pneumatic Conveying. By E. G. Phillips. (Pitman's Technical Primers.) Pp. xii + 108. (London: Sir Isaac Pitman and Sons, Ltd., 1921.) 2*s.* 6*d.* net.

PNEUMATIC conveying is one of the so-called labour-saving devices, the usefulness of which has been recognised only comparatively recently. In the little book under notice Mr. Phillips sets forth the principles underlying the construction of pneumatic conveying systems and gives an account of some of the various uses to which this means of transport can be adapted. The first portion of the book deals with the different systems in use, and pumps, dischargers, pipe lines, suction nozzles, and other details of the necessary plant are described. Then follow chapters on grain and coal-handling plants and on the induction and the steam-jet conveyor. The concluding chapter recounts some of the multitudinous uses to which this extraordinarily adaptable and flexible method of transport can be put.

Small Single Phase Transformers. By Edgar T. Painton. (Pitman's Technical Primers.) Pp. x + 95. (London: Sir Isaac Pitman and Sons, Ltd., 1921.) 2*s.* 6*d.* net.

THE scope of this practical little volume is sufficiently indicated by the sub-title, "Explaining a Commercial Method of Design. Making Possible Economy of Material and Accurate Predetermination of Characteristics, and Giving Information Enabling the Amateur to Design and Construct a Transformer Meeting his own Requirements." The same attention does not appear to have been given hitherto to effecting economies in the design of very small transformers as to that of large apparatus, and the author's way of attacking the problem should prove of use in this respect.

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.]*

Fossil Buttercups.

IT is remarkable, as Prof. Cockerell points out in NATURE of January 12, p. 42, that until his discovery of a Miocene buttercup no species of the family Ranunculaceæ should have been recorded among the fossil plants of North America. More especially is this the case because the carpels of Ranunculus are among the commonest fossils found in deposits of Pleistocene and Pliocene age in Britain and the neighbouring parts of the Continent. Among the many lists of fossils determined by my husband and myself from such deposits, in one only, the Pliocene of Bidart (Basses-Pyrénées), is the genus not represented, and in this deposit very few species of any kind were found.

The oldest carpel I have seen is that of an extinct batrachian Ranunculus (*R. gailensis*, E. M. Reid), very thick-walled and globose, from the base of the Pliocene of Pont-de-Gail (Cantal). From the same horizon, but another locality in Cantal, M. Pierre Marty recorded *R. ctavorum*, Sap., which he considers nearly related to *R. fluitans*. It is quite probable, though it has not been proved, that carpel and leaf belong to the same species.

In the latest Pliocene of the Cromer Forest-bed, with the exception of two undetermined carpels, all are British species. In the Upper Pliocene of Tegelen (Holland) *R. aquatilis* and *R. repens* are found associated with *R. nodiflorus*, a species of Central Europe and the Orient, and with a single specimen of a peculiar form of *R. sceleratus* found more abundantly at Castle Eden. In the Middle Pliocene of Castle Eden no definite West European species is found, though the form of *R. sceleratus* already mentioned and a peculiar batrachian Ranunculus, both probably extinct, occur associated with two Central European species, *R. nodiflorus* and a varietal form (perhaps extinct) of *R. lateriflorus*, also an extinct species of which the affinity has not been discovered. In the Lower Pliocene of the Dutch-Prussian border the only West European species is *R. nemorosus*; it occurs associated with *R. nodiflorus*, *R. lateriflorus*, var., and the South European species *R. brutius*. In the lowest Pliocene of Pont-de-Gail one specifically indeterminable carpel and the batrachian *R. gailensis*, already referred to, were found.

Among the hundreds of Pleistocene and Pliocene specimens examined none has shown indications of two seeds, but I have not been able to carry the record of the genus so far back as Prof. Cockerell.

In the work here referred to the carpels were in every case obtained by "washing" the material and sieving away the matrix. Were this method applied to some of the North American Pleistocene and Tertiary deposits I should anticipate that they might yield, not only abundant carpels of Ranunculus, but the fruits and seeds of many other herbaceous plants.

ELEANOR M. REID.

Pinewood, Milford-on-Sea, January 23.

The Accuracy of Tide-predicting Machines.

IN the article in NATURE for November 24 last appearing under the title "British Research on Tides" there occurs a statement which may, perhaps, leave an erroneous impression with those not familiar with tide-predicting machines. The statement in question —"a test of the accuracy of the tide-predicting machines used by the Admiralty and the India Office has indicated some serious errors in their results, and it is concluded that the labour of reading the curves afforded by the machines, with any pretence to accuracy, is comparable with the labour of direct computation, while the value of the results is greater in the latter case"—although made definitely with reference to particular tide-predicting machines, might, nevertheless, leave the impression that tide-predicting machines in general were subject to "serious errors in their results." It therefore appears of value to discuss briefly the subject of the accuracy of tide-predicting machines and to refer to some tests made with a direct-reading type of tide predictor.

Tide-predicting machines, or tide predictors as they are frequently called, make use of the harmonic tidal constants, and are contrived for the purpose of summing a number of terms of the form $A\cos(at+\alpha)$, in which for each harmonic constant A is the amplitude, a the speed per unit time t, and α the initial phase. For any given port, therefore, the height of the tide at any time is the instantaneous sum of the simple constituent tides represented by the harmonic constants. And in the tide predictor this instantaneous summation is effected by means of a flexible chain which passes alternately over and under a series of pulleys the motion of each of which represents the changes in elevation of a particular simple tide.

The accuracy of a tide predictor is therefore to be measured by the accuracy with which it sums the simple constituent tides represented by the harmonic constants. It is necessary to emphasise this, for not infrequently one meets with the assumption that the accuracy of the tidal predictions tests the accuracy of the tide predictor. Tidal predictions are the product of the tide predictor, and for any given port aim to give in advance the times and heights of high and low water. And the test of the accuracy of these tidal predictions is, obviously, the closeness of agreement with the tides as they actually occur.

It is to be noted, however, that the times and heights of the normal or predictable tide are subject to the disturbing effects of variations in wind, atmospheric pressure, rainfall, and seiche. Hence, altogether apart from any imperfections in the tide predictor or in the harmonic analysis which separates out the simple constituent tides, tidal predictions may differ from the observed times and heights of the tide, due to the disturbing effects just mentioned, the times of occurrence of which cannot be foreseen at the time the tidal predictions are made. It is, therefore, obvious that, while in a measure the accuracy of the tidal predictions tests all the processes entering into their making, it does not strictly test the accuracy of the tide predictor.

Tide predictors are of two types, which we may denominate respectively as curve-tracing machines and direct-reading machines. In the former there is traced, to a suitable scale on a sheet of paper, a curve of the predicted tide from which the height of the tide at any given time or the times and heights of high and low water may be scaled. In the direct-reading tide predictor the height of the tide at any time, and also the times and heights of high and low water, are indicated on dials from which they are read off directly.

It is obvious that the prediction of tides can be carried out more rapidly with a direct-reading tide predictor than with the curve-tracing type, for reading figures from two or three dials is less time-consuming than scaling these same values from a curve. But

even apart from its greater economy in time, the direct-reading machine has a still further advantage in that it is possible to secure more accurate results than with the use of the curve-tracing type. The dials on the direct-reading tide predictor are graduated to single minutes and to single tenths of a foot; it is, therefore, not difficult to estimate to within half a minute or five hundredths of a foot. To estimate as closely from a curve drawn to a moderate time-and-height scale is well-nigh impossible.

Since the tide predictor sums a number of continuous functions, it cannot be made to give the exact results of an adding or a multiplying machine. And because of the large number of moving parts that enter into the construction of a tide predictor, we cannot hope to secure the accuracy that may be obtained with a planimeter. In fact, the errors of the tide predictor may be ascribed almost wholly to the varying tensions on the numerous moving parts, but it appears that these errors should not be large enough to be serious.

In 1910 the U.S. Coast and Geodetic Survey put into operation a direct-reading tide predictor which had been constructed in its instrument division. Prior to the use of this machine for the prediction of tides for the annual tide tables it was carefully tested, one of the tests consisting in the comparison of the hourly heights of the tide as given by the machine and as computed analytically "by hand." The machine was set with 30 components for Hong Kong, China, January 1, 1912, and run through to December 31. For that day hourly heights of the tide were read off for the entire twenty-four hours.

At the beginning of this year, after it had been in use about twelve years, the machine was again set for Hong Kong, January 1, 1912, and run through to December 31, and the hourly heights read off. December 31 was chosen so that all errors due to the incommensurability of the speeds of the various components might accumulate. The table below shows the differences between the computed and the predicted heights:—

Hourly Heights of Tide, Hong Kong, China, December 31, 1912.

Hour	Predicted in 1910. Feet.	Predicted in 1922. Feet.	Computed. Feet.	Differences 1910. Feet.	Differences 1922. Feet.
0	4·28	4·30	4·32	−0·04	−0·02
1	4·65	4·67	4·68	−0·03	−0·01
2	4·78	4·78	4·80	−0·02	−0·02
3	4·60	4·61	4·59	+0·01	+0·02
4	4·07	4·08	4·05	+0·02	+0·03
5	3·27	3·27	3·22	+0·05	+0·05
6	2·32	2·32	2·28	+0·04	+0·04
7	1·42	1·42	1·37	+0·05	+0·05
8	0·70	0·70	0·66	+0·04	+0·04
9	0·31	0·31	0·27	+0·04	+0·04
10	0·34	0·33	0·33	+0·01	0·00
11	0·76	0·78	0·81	−0·05	−0·03
12	1·51	1·52	1·56	−0·05	−0·04
13	2·31	2·32	2·37	−0·06	−0·05
14	3·00	3·01	3·06	−0·06	−0·05
15	3·48	3·48	3·53	−0·05	−0·05
16	3·70	3·68	3·73	−0·03	−0·05
17	3·64	3·63	3·66	−0·02	−0·03
18	3·38	3·38	3·40	−0·02	−0·02
19	3·04	3·06	3·07	−0·03	−0·01
20	2·73	2·74	2·75	−0·02	−0·01
21	2·50	2·52	2·51	−0·01	+0·01
22	2·46	2·47	2·47	−0·01	0·00
23	2·64	2·66	2·67	−0·03	−0·01

It is to be noted that the height-scale on the tide predictor is graduated to tenths, so that the hundredths were estimated. The differences between the heights as predicted and as computed are relatively small, in no case exceeding 0·06 ft. It is also interesting to note the close agreement between the predictions made in 1910 and those in 1922, these predictions being made not only twelve years apart, but also by different persons. It is only proper to add that these predictions were undoubtedly carried out with more than ordinary care, owing to the psychological effect of the knowledge that a test was involved. Furthermore, it must be stated that with a single-component tide the accuracy attained was not so gratifying as in the example given above, the reason being that with a number of components there are compensating tensions of the moving parts, while with a single component there are no such compensations. It is to be borne in mind, however, that in the prediction of tides there is always a considerable number of components involved.

It would be unfortunate if the impression that tide predictors are subject to serious errors gained currency, for, apart from the use of such machines for the prediction of tides for the tide-tables, there are numerous tidal problems involving time-consuming computations which may be very easily made with the tide predictor. In the elimination of the effects of short-period tides on daily mean sea-level, in the computation of the changes in sea-level due to tides of long period, in the elimination from the observed tide of the tide due to a number of constituents, and in similar problems, the tide predictor should very materially lessen the laborious computations involved.

H. A. MARMER.
U.S. Coast and Geodetic Survey, Washington, D.C., January 5.

THE errors found in the British tide-predicting machines referred to in the article were more serious than those described by Mr. Marmer. The machines were of the curve-tracing type, and therefore inevitably less accurate (with the time and height scales ordinarily used) than direct-reading machines; they had zero errors, and also diminished the apparent range of the tide. The direct-reading machine used by Mr. Marmer is both more accurate and quicker in use; for many purposes, though perhaps not for all, such a machine is a valuable substitute for numerical computation.

THE WRITER OF THE ARTICLE.

The Oxidation of Ammonia.

THE following details of the early history of the oxidation of ammonia, a process which became of great importance during the war, do not appear generally to be known, and may be of interest. The first clear statement of the oxidation of ammonia which I have seen is contained in a paper by the Rev. Isaac Milner, B.D., F.R.S., president of Queens' College, Cambridge, published in the Philosophical Transactions for 1789 (vol. 79, pt. 2, pp. 300–13), and republished in Crell's *Annalen* (1795, pt. 1, pp. 550–62). The title of the English paper is "On the Production of Nitrous Acid and Nitrous Air," and the German paper is a translation, in which "nitrous acid" is rendered "Saltpetersäure" and "nitrous air" (*i.e.* nitric oxide, NO) "Saltpeterluft."

Milner remarks that, although the relation between nitrous acid and the volatile alkali was known, there was no known case in which the latter was used in the production of nitrous acid or nitrous gas. In

March, 1788, he tried the experiment of fitting a retort containing caustic volatile alkali to a gun-barrel filled with crushed pyrolusite (maganese dioxide), and heating the latter to redness, whilst the retort was also heated. Signs of nitrous acid and nitrous air soon made themselves manifest, and by continuing long enough nitrous gas was obtained. The experiment was repeated many times; its success depended on the nature of the pyrolusite, the temperature of the furnace, and the patience of the experimenter. Full details are given as to the best way of carrying out the experiment. It frequently happens that the ammonia passes over unchanged. Red lead was found, unexpectedly, not to be active, but green vitriol burnt white gave better results.

The changes are correctly explained by Milner as due to oxidation. With burnt alum he obtained the curious result of the evolution of a large amount of inflammable gas mixed with hepatic air (sulphuretted hydrogen) and sulphur, whilst sulphur remained in the gun-barrel. It is, therefore, not sufficient merely to bring the volatile alkali in contact with a substance containing dephlogisticated air, but another substance is also necessary which has a strong attraction for the combustible substance.

It is also noteworthy that Black in his "Lectures on Chemistry" (edited by John Robison, Edinburgh, 1803) states that "our newspapers inform us that the French chemists procured saltpetre for the Army by blowing alkaline gas, and even putrid steams, through red-hot substances which readily yield oxygen" (vol. 2, p. 245); and there is a statement that "Mr. Milner of Oxford (*sic*) published a paper in the 79th volume of the Philosophical Transactions . . . but he did not attempt to ascertain how much of the nitrous acid might be produced from a limited and known quantity of the volatile alkali" (vol. 2, p. 455). Black (*ibid.*) gives a clear explanation of the process; the ammonia "is a compound of hydrogen and azote, we need only suppose that part of it is totally decomposed and destroyed by the action of the oxygen contained in the manganese. Part of it, uniting with the hydrogen, forms water or watery vapour; and part, uniting with the azote, forms vapours of nitrous acid." I have not traced the reference to the "newspapers," but a footnote on the same page (455) reads: "*January*, 1796. There is a rumour that the French have manufactured saltpetre, during a part of the war, by obtaining nitrous acid from the vapours of volatile alkali, forced to pass through red hot manganese. Author."

Many strange names have of late been given to the process of ammonia oxidation; we have heard of the "Ostwald-Mittasch process" and others. The first use of platinum as a catalyst appears to be due to Kuhlmann, of Lille, in 1839.

J. R. PARTINGTON.
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A Specimen of Wrought-iron Currency from the Kisi Country, Sierra Leone Protectorate, West Africa.

A SPECIMEN of iron currency from the Kisi country was obtained by one of us (E. R. M.) while on service in West Africa in 1915 through the agency of his servant, Ali Badara, the son of a chief in the adjoining Momo-Fullah country; and a description of it may be of interest to readers of NATURE.

As this form of currency ceased to be used after the establishment of the British Protectorate in 1787, the age of the specimen may be estimated at not less than 130 years, and probably more.

The "coin" (Fig. 1) is of rough workmanship, and consists of a strip of roughly forged rectangular section, one half being twisted and the ends hammered out into thin blade-like projections, the broad end serving to prevent the "coin" slipping through the belt in which it is carried.

Analysis shows the metal to be wrought-iron of good quality, probably made by the direct process of reducing an oxide ore by carbon in presence of a basic slag containing much iron oxide to prevent carburisation of the iron, most of the slag then being

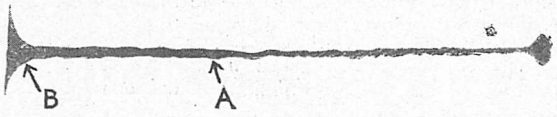

FIG. 1.—Photomicrograph × 1/5.

expressed by hammering the pasty mixture of iron and slag. The percentage composition is as follows: Carbon, 0·095; silicon, 0·103; manganese, nil; sulphur, 0·024; and phosphorus, 0·046. For the analysis drillings were taken from the wider part of the specimen and fragments from the narrow end. These were washed in benzene to remove the coating of black grease from the surface of the metal.

The metal is extremely soft and easily bent, the Brinell hardness at the point A being 121 (using a ball 1 mm. diameter and a load of 10 kilograms). A small fragment was cut from the point B, embedded in solder, polished, etched with 2 per cent. nitric acid in alcohol, and photomicrographed. The photomicrograph (Fig. 2) shows the typical crystalline structure of a pure iron, together with elongated inclusions of slag.

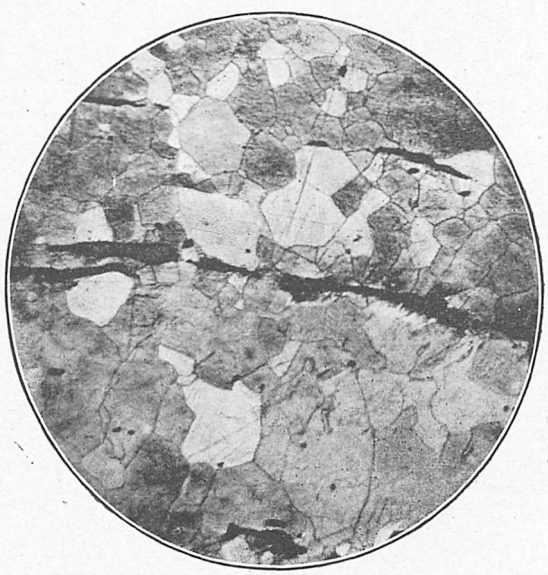

FIG. 2.—Photomicrograph × 275.

R. C. GALE.
E. R. MACPHERSON.
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Molecular Structure of Amorphous Solids.

A QUESTION of fundamental importance in the theory of the solid state is the nature of the arrangement of the ultimate particles in amorphous or vitreous bodies, of which glass is the most familiar example. Is it to be supposed that the molecules are packed

together at more or less uniform distances apart, as in crystals, the orientation of individual molecules or of groups of molecules being, however, arbitrary? Or, on the other hand, is the spacing of the molecules itself irregular, the solid exhibiting in a more or less *permanent form* local fluctuations of density similar to those that arise *transitorily* in liquids owing to the movement of the molecules? The physical properties of amorphous solids, notably their softening and viscous flow below the temperature of complete fusion, would tend to support the latter view, but the possibility of a closer approximation to the crystalline state should not entirely be ruled out, especially in view of the very interesting recent work of Lord Rayleigh on the feeble double refraction exhibited by fused silica (Proc. Roy. Soc., 1920, p. 284). A good deal might be expected to depend on the nature of the material, its mode of preparation, and heat treatment. A material formed by simple fusion and resolidification of comparatively simple molecules, such as silicon dioxide, might stand on a different footing from a material such as ordinary glass built up by chemical action and formation of complex silicates.

If the arrangement of molecules in a vitreous body were irregular, the local fluctuations of optical density would result in a strong scattering of a beam of light passing through it, the intensity of such scattering being comparable with that occurring in the liquid state at the temperature of fusion of the material (see note by the present writer in NATURE of November 24 last, p. 402). On the other hand, if the arrangement of the molecules approximated to the crystalline state the scattering of light would be merely that due to the thermal movements of the molecules and would be much smaller. As a matter of fact, glasses exhibit a very strong scattering of light, some 300 to 500 times as strong as in dust-free air, the Tyndall cone being of a beautiful sky-blue colour and nearly, but not quite, completely polarised when viewed in a transverse direction. (Some glasses exhibit a green, yellow, or pink fluorescence when a beam of sunlight is focussed within them, and cannot be used for the present purpose; the fluorescence, even when very feeble, can be detected by the difference in colour of the two images of the Tyndall cone seen through a double-image prism.) Rayleigh, who observed the light-scattering in glass, attributed it to inclusions, some of which he assumed must be comparable in size with the wave-length (Proc. Roy. Soc., 1919, p. 476). The closest scrutiny through the microscope under powerful dark-ground illumination fails, however, to indicate the presence of any such inclusions, and it seems more reasonable to assume, in view of the foregoing remarks, that the scattering is really molecular. Its magnitude is of the order that might be expected on the basis of a non-uniform distribution of the molecules.

Further observations with specially prepared glasses and with fused silica would be of great interest to investigate the influence of the chemical constitution and heat treatment on the molecular *texture* of the solid. C. V. RAMAN.

210 Bowbazaar Street, Calcutta, December 29.

Forecasting Annual Rainfalls.

IN NATURE of September 1 last, p. 12, in commenting on the remarkable rainfall at Blue Hill Observatory, Mass., in July, 1921, departures from mean monthly amounts were given to show that the locality was experiencing a period of excess of rainfall. Furthermore, it was intimated that the annual amount for 1921 would exceed the 35-year normal by 150 mm. (5·90 in.). The excess actually was 136 mm. (5·35 in.) and practically a verification.

Many things must be considered in forecasting annual rainfalls, even after the year is well advanced, and no one appreciates the uncertainties better than the professional forecaster. All forecasting is hazardous, but weather forecasting is especially so.

Perhaps the most important factor in estimating the seasonal trend is the strength and location of the North Atlantic infrabar (the "centre of action" of Teisserenc de Bort).

In "The Winds of Boston" (Harvard College Observatory Annals, vol. 73, pt. 3, and vol. 83, pt. 1) the relation between surface-flow of the air and rainfall is given in some detail. A preponderance of east and south-east winds is evident during a rainy season.

The rainfall of 1921 supports the views there given. There was a marked deficiency of west-north-west wind and a marked excess of north-east to south-east wind. The average durations, 37-year normal, are: West, 1708 hours; north-west, 1543 hours; and north, 835 hours. In 1921 these values were decreased 14 per cent., 34 per cent., and 20 per cent. The excess of east wind is even more noticeable. Average durations are: East, 617 hours; south-east, 560 hours; and north-east, 838 hours. The deficiencies were: East, 57 per cent.; south-east, 47 per cent.; and east, 27 per cent.

A just estimate of the character of a season or of a year cannot be based absolutely on the quantity or duration of rain. One torrential rain lasting a few hours can offset weeks of rainless weather. At Blue Hill, fortunately, such occurrences are rare.

A striking illustration of the untrustworthiness of rainfall as a criterion of season is found in the recent flood in Texas. At Taylor, on September 9, 1921, following two months of drought, there was a rainfall of 587 mm. in twenty-four hours. This is the greatest daily rainfall yet reported in the United States following two months without any rain. This city had as much rain in one day as London gets in a year, yet the mean annual rainfalls of the two localities are not markedly different, being 620 mm. for London and about 970 mm. for the Texas city. Note that the latter locality received 60 per cent. of an annual rainfall in twenty-four hours. Such an accidental fall must be eliminated, or any effort to correlate pressure distribution, surface flow, and rain becomes futile. Furthermore, it would seem that efforts to link up variation in solar output and seasonal conditions as determined by the amount of rain are open to question. ALEXANDER MCADIE.

Harvard University, Blue Hill Observatory,
Readville, Mass., January 7.

Units in Aeronautics.

THE present writer's original letter was phrased with scrupulous care to limit consideration to the single proposition that consistency cannot be maintained in dynamical equations if gravity units are used in expressing inertia forces, in particular not by merging explicit g in the slug. An example was given so conclusive as to elicit, it was hoped, Prof. Bairstow's own explanation of the statement cited from his text-book.

No opinion was then offered on the validity of the relation $R = k\rho SV^2$, or on the merits of the poundal and dyne. The courtesy of this column would scarcely stretch to the detailed statement of the writer's position in respect of opinions attributed to him by implication on these and other apparently digressive points raised by Mr. Rowell and Sir George Greenhill. A. R. LOW.

Some Problems of Long-distance Radio-telegraphy.[1]

By DR. J. A. FLEMING, F.R.S.

I.

THE achievement of transatlantic radio-telegraphy in 1901 and 1902 was of interest to physicists chiefly by reason of the fact that they did not see clearly why it should have been possible at all. The mystery of it was increased when at later dates radio signals were transmitted a quarter of the way round the world, and finally, with high-power stations and thermionic valves detected even at the Antipodes.

The wave-length of the waves used in the earliest work at Poldhu was about 3000 ft. The earth, roughly speaking, is a sphere 42 million feet in diameter. Hence the ratio of wave-length then used to earth diameter was about 1 : 14,000.

In the case of light there is a small bending or diffraction of the wave round an opaque obstacle. In other words, there is some small amount of illumination within the boundary of the geometrical shadow. The average wave-length of light waves is about 1/2000th of a millimetre, and a sphere having a diameter of 7 mm. would be 14,000 of such wave-lengths. Now if an exceedingly small source of light were placed on the pole of a sphere 7 mm. in diameter in a dark region, it is certain that there would be no illumination at the equator of the sphere. In other words, there would not be any sensible diffraction at an angular distance of 90°. Modern long-distance radio-telegraphy conducted with waves of wave-length approximating to 10 miles or so can communicate even with the Antipodes.

The mathematical treatment of the problem of the diffraction round a conducting sphere of electric waves which are radiated from a transmitter at its pole consists in expressing the magnetic and electric forces at any angular distance θ in the form of a series of harmonic terms. It is in the summation of this series to obtain the integral effect at the receiver that the chief difficulties and differences of opinion occur, and most analysts have employed only an approximation. In 1918 Prof. G. N. Watson effected a new and complete summation which enables the value of the forces to be calculated for any point on an imperfectly conducting sphere.

The result of eighteen years' work on this problem by mathematicians of the highest rank has been to give us a formula for the current in a receiving aerial of given resistance determined in terms of wave-length, aerial heights, and distance which represents the result of pure diffraction acting round a spherical earth of perfect conductivity. On the other hand, when we come to compare the results of this diffraction formula with actual observations in practice we find an enormous discrepancy. The actual received currents in the case of long-distance stations for the usual sending aerial currents are hundreds of thousands, or even millions, of times greater than the received current predicted by the theoretical formula. Thus, to take a case quoted by Dr. Van der Pol from observations made at Darien Radio Station, on the Panama Canal, on radio signals sent from Nauen, near Berlin, Dr. L. W. Austin gives the following figures: $I_1 = 150$ amperes, $\lambda = 9{\cdot}4$ km., $a_1h_1 = 120$ metres, $a_2h_2 = 146$ metres, $R_2 = 29$ ohms, and $d = 9400$ km. Now the actual received current was $I_2 = 1{\cdot}3$ microamperes, but the value predetermined by the formula is only 0·6 of one millionth of a microampere. In other words, the actual received current in this case is two million times greater than the predicted current.

The upshot of the whole matter then is this: Long-distance radio-telegraphy, say, round one-quarter of the circumference of the earth, would certainly be quite impossible but for some cause, other than diffraction, operating to compel the waves to follow round the earth's curvature and not quickly glide off it.

Oliver Heaviside in 1900 suggested that an upper conductive layer on the atmosphere might act as a guide to the waves, radio-telegraphy being, in fact, conducted in a thin spherical shell of non-conductive air bounded by a conductive earth and a conductive upper air. He did not furnish any valid reasons to explain why this upper air conducts and how its conductivity is preserved, and although the suggestion has been very generally accepted by radio engineers, it has been taken without sufficient criticism of its difficulties and details. There has been in the intervening twenty-one years an immense accumulation of facts, all showing, however, that long-distance radio-telegraphy is conditioned by the physical constitution of our atmosphere and is very far removed indeed from being simple electromagnetic wave propagation in empty space. An important epoch in this connection is the year 1902, when Senatore Marconi discovered during one of his early voyages across the Atlantic in the s.s. *Philadelphia* in February, 1902, that radio signals from Poldhu could be received at night about thrice the distance they could be read in daytime, being detectable only up to 700 miles by day, but readable up to 2099 miles by night.

It was at once surmised that the difference was due to ionisation of the air by sunlight, which, by liberating electrons from atoms, gives to the air conductivity. It was some years before this vague suggestion was converted by Dr. W. H. Eccles into a more definite scientific theory, many speculations in the meantime being found wanting in adequate basis, such as that which regarded the sunlit air as having an absorption for the energy of electromagnetic waves similar to that of foggy or misty air for visible light.

[1] Abridged from two sections of the Trueman Wood lecture on "The Coming of Age of Long-distance Radio-telegraphy and Some of its Scientific Problems," delivered before the Royal Society of Arts on November 23, 1921. The complete lecture is published in the Journal of the Society for December 9 and 16, 1921.

Before entering into further discussions of the facts, it will be convenient to mention a few of the generally accepted views as to the constitution of the terrestrial atmosphere and its ionisation by light.

By the use of hydrogen-filled sounding balloons carrying self-recording meteorographs, it has been possible to explore the atmosphere up to a height of about twenty miles. One of the results is to show that our atmosphere may roughly be divided into two regions. In the lower layer, called the *troposphere*, the atmospheric gases are kept well mixed up by winds and convection. This layer extends to a height of six or seven miles or so, and in it the temperature falls regularly with increasing height at the rate of about 6° C. per kilometre of ascent until a temperature of about −55° C. is reached. Above this is a zone called the *stratosphere*, of unknown thickness, in which the temperature remains constant. Above a height of about seven miles water vapour is absent, and at higher levels convection ceases to operate and the atmospheric gases arrange themselves in order of density. The outer and highest levels above a height of sixty miles (=100 km.) are chiefly composed of helium and hydrogen with possibly some small admixture of the rarer atmospheric gases neon and krypton.

The volume composition of the atmosphere at the earth's surface is as follows:—

Nitrogen	...	78·05 per cent.
Oxygen	...	21·00 „
Argon	...	0·93 „
Carbon dioxide		0·03 „
Hydrogen	...	1 to 10 vols. in a million of air.
Neon	...	10 „ „
Helium	...	1 to 2 „ „
Krypton	...	1 vol. „ „
Xenon	...	0·05 „ „ „

Oxygen is almost entirely absent at a height of 100 km., but nitrogen is still present in a rarefied form. The presence of hydrogen and helium at these high levels has been indicated by an observation of Pickering on the spectrum of a meteoric stone entering the earth's atmosphere, which showed the hydrogen and helium lines.

Next, as regards the action of light on the gases of the atmosphere. Light waves of high refrangibility impinging on nearly all substances, especially those containing electropositive atoms, liberate from them electrons. The atom is now considered to be a collocation of negative electrons arranged in concentric shells, possibly in orbital motion, round a central positively charged nucleus in which the gravitative mass of the atom chiefly resides. Light of short wave-length causes one or more of these negative electrons to be detached and projected with a high velocity. The more electronegative an atom is the higher must be the frequency of the light to affect it. The electrons so detached are called photo-electrons and the action photo-electric.

In the case of sodium or potassium, which are highly electropositive metals, photo-electrons are emitted under the action of visible light, about the middle of the spectrum, but for less electropositive metals—*e.g.* zinc and magnesium—the action takes place only with ultra-violet light. Hence it follows that a plate of zinc illuminated by light from an electric arc or by the spark between aluminium balls loses a negative charge readily, and if insulated, becomes positively electrified owing to the loss of negative photo-electrons. The velocity with which these photo-electrons are projected is considerable, and may be 500–1000 km. per sec.

For most metals the ionising potential is about two to four volts, hence the maximum wave-length of ionising light is just beyond the violet end of the visible spectrum. But for atmospheric gases, when pure and free from dust or moisture, the ionising potential is much higher, being approximately as follows:—

Nitrogen	...	7·5 volts	Argon	...	12 volts
Oxygen	...	9 „	Neon	...	16 „
Hydrogen	...	11 „	Helium	...	20·5 „

It follows from this that the atmospheric gases cannot be ionised by light of longer wave-length than 1350 Å.U. Rays of this short wave-length are not transmitted by quartz but only by certain samples of fluorite, and are absorbed by a very small thickness of air. No sunlight of shorter wave-length than about 2950 Å.U. reaches the earth's surface, as shown long ago by Huggins and Cornu.

Hence the conclusion is forced on us that pure dust-free atmospheric gases cannot be ionised at the lower levels of the atmosphere by the direct action of sunlight, but at the higher levels above 60 to 100 km. doubtless there is direct ionisation.

Nevertheless, ionisation does take place in the lower atmospheric levels, as shown by the small finite electric conductivity possessed by the air, which proves that there are negative ions, either free electrons, or electrons attached to neutral atoms, and also positive ions present in the air, even over wide oceans. Thus, Boltzmann found in tests made in mid-Atlantic 1150 positive and 800 negative ions per c.c. of air. A. S. Eve found 600 to 1400 positive and 500 to 1000 negative ions per c.c., the positive being slightly in excess.

This ionisation may be produced either by photo-electric action on dust or ice particles in the air, by radio-active matter in the soil, by photo-electric action upon complex gaseous molecules in the air, or generated by the light and called condensation nuclei. Such agencies, however, cannot account for the far larger and permanent ionisation necessary to give the required electric conductivity in the higher atmosphere if it is to act as a guide to long electromagnetic waves.

A consideration of the terrestrial radio-telegraph problem shows that if there is any conductive layer in the upper atmosphere which can act as a guide to long electromagnetic waves round the earth, it must possess the following properties:—

(1) It must be permanently ionised, which means that its ionisation must not vanish in the night-time since, so far as we know, its guiding powers are not suspended on the shadow side of the earth. This seems to imply that the ionisation must be predominantly of one sign or that the *plus* and

minus ions are so far separated that they do not readily recombine. True gaseous photo-ionisation always produces ions of both signs in equal number mixed up together, and the conductivity quickly disappears when the ionising agency is withdrawn.

(2) The resulting electric conductivity must be sufficiently high, say, as good as that of ordinary fresh water, to act as a true wave guide. This implies that the ions must be very numerous per c.c. and very mobile or have high ionic velocities under unit electric force.

Bearing in mind that the upper regions of the earth's atmosphere above the 100 km. level probably consist chiefly of hydrogen, and that the velocity of ions in hydrogen under unit electric force is, according to measurements, from two to three times that in oxygen or nitrogen at the same pressure, it is easily seen that in the upper hydrogen levels of the atmosphere a very moderate amount of ionisation, say, 10^7 ions per c.c., might give a conductivity of the order of that of fresh water, or about 700,000 ohms per c.c. Another quality this conducting layer must possess if it is to act as a true reflector of long waves is a somewhat sharply defined lower surface.

It has already been remarked that observations on signal strength over long distances show an enormous difference between the actual measured values and those predicted by a simple diffraction formula. Attempts have been made to find an empirical formula for the received current in terms of the other quantities involved. At first these efforts started with the erroneous assumption that the attenuation might be regarded as due to an "absorption" caused by the atmosphere, and therefore mathematically represented by an exponential factor appended to the simple Hertzian expression for the magnetic or electric force at a known distance on the equatorial plane of a small oscillator.

Prof. G. N. Watson finds that if in place of a perfectly conducting spherical earth in free space we assume an earth having a conductivity about the same as sea water, enclosed in a spherical sheath or shell of material having a conductivity of about $1{\cdot}44 \times 10^{-15}$ E.M.U., equal to a specific resistance of 700,000 ohms per c.c. or not far from that of ordinary fresh water, the interspace being about 100 km., then the diffraction formula for the receiving aerial current would have to be modified and the exponential factor becomes $\epsilon^{-9{\cdot}6\theta/\sqrt{\lambda}}$. Watson therefore considers that if we are able to assume an upper conducting layer in the atmosphere at a height of about 100 km. having a fairly sharp under-surface and a specific resistance of about 700,000 ohms or, say, 0·75 megohm per c.c., then guided wave propagation through the included spherical shell of insulating air would account for the observed attenuation in actual terrestrial long-distance radio-telegraphy.

We have then to consider what are the probabilities and possibilities for the existence at a height of 100 km. or so of such a conducting layer and how it may be supposed to become ionised. Gaseous conductivity is always and only due to the presence of ions, and in the above case these are created by the strong electromotive forces brought into play. In gases contained in glass vessels there are always some few free ions or electrons present for some reason. If a high frequency magnetic field is made to act on the gas these ions are driven with great force against the gas molecules and ionise them, thus producing very quickly a copious supply of ions and giving the gas high conductivity. We cannot, however, say that a rarefied gas is a good conductor *per se* for very feeble impressed electromotive forces as we can say that a metal is a good conductor. Hence mere rarefaction due to height will not bestow the required electric conductivity on the atmosphere. Neither can the required ionisation be produced by solar light, because then it would vanish in the night-time by recombination of the ions.

The suggestion I wish to make as to the cause of this ionisation is based upon a modification of hypotheses already advanced by S. Arrhenius, K. Birkeland, and W. J. Humphreys concerning the projection of dust by light pressure from the sun.

We know that the sun's photosphere is in a continual state of disturbance due no doubt to violent explosions in regions beneath this light-giving locality. Above this photosphere lies the so-called reversing layer composed of metallic vapours which produce the Fraunhofer lines in the spectrum. These eruptions carry up not only metallic vapours, but also vast masses of the superlying chromosphere composed chiefly of hydrogen and helium gases in the form of solar prominences or red flames which are often seen rising to a height of several hundred thousand kilometres in a few minutes, thus indicating velocities of several hundred kilometres per second. When these solar metallic vapours are thus carried up into colder regions they must be condensed into a metallic mist or rain composed of particles of various sizes. We know also from experiment as well as theory that light exercises a pressure on solid objects and that this pressure per square centimetre for totally absorbing or black bodies is numerically equal to the light energy in the cubic centimetre. Measurements made of the so-called solar constant at the earth's surface when corrected for atmospheric absorption give a value of 2·5 gram calories per sq. cm. per min. Hence the energy of light per c.c. is nearly $6/10^5$ ergs and the light pressure therefore $6/10^5$ dynes per sq. cm. on a black surface. But at the sun's surface this pressure is 46,000 times greater, or 2·75 dynes per sq. cm. As this pressure varies as the square of the linear dimensions of the particle whilst gravitation varies as the cube, it is clear that as the dimensions of a particle decrease a limit will be reached at which the light pressure will overbalance the gravitation attraction.

It is easy to prove from known data that at or near the sun's surfaces black particles of the density of water would be just repelled if they had diameters of 15,000 Å.U. $= 150/10^6$ cm.

If their density is 5·5, then the critical diameter

will be 2700 Å.U. If, however, the particles have diameters of only 1600 Å.U. and unit density the light pressure will be nineteen times greater than the gravitation attraction. For sizes still smaller the light pressure would decrease again, and for diameters less than 500 Å.U. gravity would once more preponderate.

If, then, the solar eruptions drive up into colder regions vapours which are condensed to liquid or solid particles, a sorting action will at once come into play. Particles above a certain diameter will be drawn back into the sun. Particles below a certain diameter will be repelled away with great force by light pressure, and particles of a certain critical diameter will remain suspended in space. The solar corona may perhaps be in part composed of solar dust of this critical diameter, as Arrhenius has suggested. Now, as regards that dust which is repelled by the sun, it is easy to calculate the time particles of certain sizes will take to travel to the earth's orbit and the velocities they will then possess. Taking the particles to have unit density and three sizes, viz. 1600, 5000, and 10,000 Å.U., and to be projected from the sun with velocities of 200 km. per sec., I find that the times required to travel to the earth's orbit will be respectively twenty-two hours, forty-two hours, and seventy-six hours. The velocities with which they will arrive will be 1700 km. per sec., 780 km. per sec., and 350 km. per sec. respectively.

These minute particles, composed, it may be, of carbon from the photosphere or metallic dust from the reversing layer or volcanic ash or other solar materials will in general carry electric charges. The high temperature will cause emission of electrons from the metallic particles, as also will the fierce ultra-violet radiation to which they are exposed. The metallic vapours will also be in a state of ionisation, and the free electrons emitted will condense round them gases or vapours from the chromosphere as they pass through it. Hence the particles which are repelled by light may be either positively or negatively electrified or neutral. Owing to the greater tendency of negative electrons to condense vapours and attach themselves to groups of molecules, the negatively charged particles may be less dense and smaller than those positively charged. It should be noted, however, that isolated molecules or electrons are far too small in diameter to be repelled by light. It is only groups of molecules of at least 500 Å.U. in diameter which can be repelled. Hence these dust particles will travel outwards from the sun with very different velocities. Some will come with great velocity and others with small speed.

In short, we may say that the sun, like a good housemaid, dislikes dust, especially dust of a certain degree of fineness, and pushes it away from it with great force. The moment that this electrified dust enters the earth's magnetic field with high velocity forces will be brought to bear on it tending to separate the negatively and the positively charged particles. If H is the magnetic force of the earth and v the particle's velocity, and e its charge, then the separating force is Hev where H is that component of magnetic force at right angles to the direction of v and the separating force is also at right angles to the plane of H and v.

(*To be continued.*)

Obituary.

SIR ERNEST SHACKLETON, C.V.O.

THE sudden death of Sir Ernest Shackleton on board the *Quest* at South Georgia on January 5 stopped the career of the most brilliant of Antarctic explorers just on the threshold of the South Polar regions which he was entering for the fifth time with his third expedition. That such a courageous and indomitable explorer should die a natural death after a lifetime of hair-breadth escapes from perils of ice, of starvation, of shipwreck, and of war is a grim stroke of Nature's irony. Great as his loss is to geographical exploration, we cannot but recognise his end as happy, for his life was arrested in the full course of the enthusiastic pursuit of a great and crowning adventure. The sympathy of all who appreciate high-hearted deeds will flow towards his wife, to whose co-operation much of his success was due; towards his shipmates, who have nobly resolved to carry on the voyage; and towards Mr. John Q. Rowett, whose friendship for Shackleton made him undertake the main financial burden of the expedition.

Ernest Henry Shackleton was born at Kilkee, in Ireland, in 1874, removed to London with his father while still a schoolboy, and at an early age insisted on going to sea instead of following his father's profession of medicine. After voyages to South America and other parts of the world, he entered the service of the Union Castle Co., where he was during the stirring days of the Boer War. He had become an officer of the Royal Naval Reserve before the plans of the Antarctic expedition on the *Discovery* fired him with the desire for exploration. His application for a post on the expedition was refused, persisted in, and finally accepted, and he had a strenuous time on board as junior watch-keeping officer. The expedition sailed in August, 1901, and from the outset Shackleton was eager to undertake every piece of voluntary work. He assisted in the chemical and oceanographical observations, assumed the editorship of the *South Polar Times*, and read up the history of polar exploration. When Capt. Scott was making up his party for the great southern journey of 1902–3 he included Shackleton, who thus took part in establishing the "farthest south" of lat. 82° 17′ S., and saw the great range of mountains bordering the Ice Barrier on the west and stretching far to the southward. On the return journey Shackleton broke down from an illness which was probably scurvy, but he struggled on to

the end without giving in, and only last year he refuted with the utmost indignation a published statement that he had been dragged on a sledge by his comrades on that occasion. He was much distressed at the decision that he should return home by the relief ship, and it may well be that this fact was the germ of the determination to return to the Antarctic with an expedition of his own. Shackleton had more than recovered by the time he reached England, and his health never gave way again.

In 1904 he became secretary of the Royal Scottish Geographical Society and took up his residence in Edinburgh after his marriage to Emily, daughter of the late Mr. Charles Dorman. It is scarcely too much to say that the breezy energy of the new secretary electrified the society. Unheard-of innovations were installed, unprecedented expenses undertaken, and a harvest of new members justified every reform. At the general election of 1906 he appeared as the Unionist candidate for Dundee and conducted a vivacious though unsuccessful campaign.

After this, secretarial duties proved too commonplace, and for a time Shackleton found a freer vent for his energies in business life, taking part in one of the great shipbuilding and engineering works on the Clyde. But all the time unseen lines of force were holding his ambition true to the south, and silently but solidly he laid his plans. He bought an old whaler, the *Nimrod*, raised a considerable sum of money under his personal guarantee of repayment if the expedition proved a success, and, profiting by the mistakes of the *Discovery* expedition, he had all his provisions prepared, packed, and stowed under his personal inspection. He had no committee and no orders, but held himself free to carry out his own plans in his own way at his own risk. He decided to base his transport on ponies and motor haulage, methods never used before in polar exploration, and although the motor broke down at an early stage, the ponies brought the expedition to a point on the barrier beyond that reached in the *Discovery* expedition, and but for the loss in a crevasse of the last pony, the South Pole would have been reached. An ascent to the plateau was found by the Beardmore Glacier, and when it was clear that the provisions could not carry the party all the way and back, Shackleton turned in lat. 88° 23′ S. Had he pushed on for another day before turning he would have met the fate which afterwards befell Scott, and, indeed, he very narrowly missed it. On this expedition there were many innovations in food, in lighting, and for the first time it carried a kinematograph into the polar regions.

On his return in 1909 the recognition of the epoch-making advances in methods and results was widespread, if not universal, and the splendid achievement of David and Mawson in reaching first the summit of Mount Erebus and then the Magnetic Pole, together with the biological, meteorological, and geological work of all the parties, gave the expedition, as a whole, high scientific value. Shackleton received a shower of gold medals from the geographical societies of the world and the honour of knighthood. He passed a strenuous year or two lecturing in Europe and America to pay off the debts of the expedition and the expense of the scientific reports.

The attainment of the South Pole by Amundsen and Scott in 1912 turned Shackleton's attention to the project of crossing the Antarctic continent by landing on the shores of the Weddell Sea and marching *via* the Pole to his old quarters on the Ross Sea. Again his word was sufficient security for the advance of funds, and again the plan was his own. The war broke out after his start in the first week of August, 1914, and he at once placed ships, stores, and men at the disposal of the Government for military service. The offer was declined, and the expedition sailed. The Ross Sea party carried out its programme and laid a chain of *depôts* from Macmurdo Strait to the Beardmore Glacier, but the men were imprisoned at their winter quarters by the drifting away of their ship, the *Aurora*. Meanwhile, Shackleton, in the *Endurance*, had carried the exploration of Coats Land farther south than its discoverer, Bruce, or his German follower, Filchner; but just when a landing was almost in sight the ship was caught and drifted northward fast in the ice step by step with the *Aurora* on the other side of the world.

The *Endurance* was crushed and sank, but Shackleton and his party kept up their courage through a dreadful year of inaction. Where reckless daring was the only course everyone knew that he would dare all; but it was a revelation to most of us to find that when safety lay in caution he could command the eager spirits of his companions to patience. When a landing was made on Elephant Island he at once decided to make for South Georgia, 800 miles away, in a little open boat with a few volunteers, and seek help for the others, who remained under the charge of Frank Wild. He made the almost impossible voyage, well knowing that if he survived and the party on Elephant Island perished he would be charged with deserting them and seeking his own safety, and to face this possibility was a greater test of courage than the Southern Ocean itself. He succeeded after three failures in bringing every man who sailed in the *Endurance* back alive to South America in August, 1916.

Hurrying to New Zealand, he found that the authorities who had repaired and equipped the *Aurora* to rescue his Ross Island party refused to allow him to take charge of his own ship to look for his own men; but he felt his responsibility so keenly that with an almost unbelievable magnanimity he accepted the situation and shipped as a common sailor on the relief voyage. Never was a case where failure was so nobly retrieved, and the failure had occurred only because the forces of Nature are stronger than the resources of the most heroic man.

For two years Shackleton served in the army as officer in charge of the supplies for the British force operating in the White Sea and Northern Russia. Then for another feverish spell he threw all his energies into lecturing on his last expedition to enable

him to repay the advances which had been made to him. Once out of debt, he found the call of the ice irresistible. He meditated a dash to the unknown centre of the Beaufort Sea in the Arctic regions, and had gone far to mature his plans when circumstances barred the way, and he resolved on one more Antarctic voyage.

This time the munificence of friends secured him freedom from financial worries. His plan was sound; the Enderby Quadrant which he was to explore was practically unknown; his old comrades rallied to him from the ends of the earth; but the ship was small though stout, and he was forty-seven years old, though a boy at heart. He sailed in the *Quest* in September, 1921, had a grievous buffeting on the voyage to Madeira, a long and trying delay for refitting in the heat of Rio de Janeiro, again a stormy voyage to South Georgia, and then the sudden seizure in the midst of apparent health, and the career of the most Elizabethan of modern explorers had an end as abrupt as the clash of "the blind Fury with the abhorred shears."

Shackleton lived like a mighty rushing wind, and the very strength of his nature made him enemies as well as friends. He resented injustice and slights, but they only spurred him on to show by new achievements how baseless they were. He endeared himself to his friends, and was adored by his ship-mates, who saw in "the Boss" a kindly but unquestionable authority. He loved applause and gloried in the limelight; but he was applauded for feats that no one else was able to accomplish. The labourer is worthy of his hire, and no one has a right to quarrel with a good workman if he likes to take some of his pay in the form of praise and publicity.

Shackleton's most characteristic quality was neither courage nor resolution, both of which he shared with other heroes of exploration. It was his instinctive judgment. Whenever he had to make a decision between two courses of action, no matter how suddenly the necessity arose nor how quickly it had to be met, he invariably did the right thing. Again and again the wrong decision would have meant certain death or irremediable disaster. This power of decision was not an effort of reason, but an apparently instinctive impulse which can perhaps be accounted for by a peculiar balance of perception. Indeed, it is to the balancing of contradictory qualities that much of Shackleton's success was due. His mind was not essentially scientific, though he valued science and made most generous provision for it in his expeditions. He was both impulsive and cautious, yet he was never irresolute. He revelled in poetry and seemed to breathe the air of romance, but at the same time he was a methodical organiser and a keen business man. His imagination was amazingly fertile, and it seems as if in planning an expedition he imaged to himself everything that could possibly happen in any set of circumstances and then set himself to work to provide for each contingency. Whatever may have been its secret, his personality was his greatest power, and it marked him out as a commanding figure. He might well have been a Drake or a Ralegh; in no time and in no conditions could he have been commonplace. The greatness of his loss may be judged by the things he did and the way he did them.

HUGH ROBERT MILL.

SIR WILLIAM CHRISTIE, K.C.B., F.R.S.

WILLIAM HENRY MAHONEY CHRISTIE was the youngest son of Samuel Hunter Christie, professor of mathematics in the Royal Military Academy at Woolwich and secretary of the Royal Society from 1837 to 1854. He was born in 1845, the same year as George Darwin and two years later than David Gill. Educated at King's College School and Trinity College, Cambridge, he was fourth wrangler in 1868, and in the following year was elected to a fellowship of his college. On the recommendation of Airy, Christie was, in the autumn of 1870, appointed chief assistant at the Royal Observatory, Greenwich. At that time the activity of the Observatory was largely concentrated on its traditional duty of the regular observation of sun, moon, planets, and fundamental stars, the stars being regarded as points of reference for the planets, and especially the moon, and serving also for the determination of time. The observations were made with the transit circle erected by Airy in 1850. Christie made a careful study of (1) the most suitable value of the refraction constant at Greenwich, (2) the corrections to be applied for a well-established and persistent difference between the zenith distances of stars when observed by reflection from mercury and when observed directly, and (3) the value of the latitude at Greenwich—data required to deduce the declinations of stars free from systematic errors. In this involved and somewhat indeterminate problem his judgment was correct, as is shown by the smallness of the systematic corrections applicable to the Greenwich catalogues of 1880, 1890, and 1900 to bring them into accord with the mean of other observatories.

The extension of the field of work of the Observatory was pressed on Airy by Warren de la Rue, who advocated continuous observations of sun spots, and by Huggins, who advocated spectroscopic observations of sun and stars. In a letter to Airy in May, 1872, Huggins writes: "I understand Mr. Christie, who is zealous in the matter, to say that you would be agreeable to this course." Government sanction was obtained, and Mr. E. W. Maunder was appointed assistant for photographic and spectroscopic observations. Christie was in sympathy with both these extensions of the activity of the Observatory. The photo-heliographic work was carried through very successfully, and arrangements made with the Solar Physics Committee, and later with the Cape and Kodaikanal Observatories, resulted in a uniform and continuous series of photographs of the sun being taken day by day, which were afterwards measured and discussed at Greenwich with reference to the positions and areas of sun spots.

The spectroscopic observations for velocity in the line of sight were not successful. It was not until the introduction of photography by Vogel that any reliance could be placed on line of sight determina-

tions of velocity, and not until the Mills spectrograph at the Lick Observatory was got into operation in 1895 by Campbell that thoroughly trustworthy results were obtained. But the earlier observers in the field, as in the parallel case of parallax determinations, deserve credit for attacking an important problem, though they did not succeed in overcoming the great difficulties which it presented.

On the retirement of Airy, in 1881, Christie was appointed Astronomer Royal. His tenure of office is notable for the large additions he made to the equipment of the Observatory and to the introduction of stellar photography. The first extension of the buildings was an additional computing room, and with it a pier and dome, which served later for the astrographic equatorial. In 1885 he represented to the Admiralty the desirability of increasing the optical means of the Observatory, and received its assent to the purchase of an object-glass of 28-in. aperture and 28-ft. focal length. In co-operation with Stokes an object-glass was proposed which might be used for visual or photographic observations. This telescope, constructed by Sir Howard Grubb, was completed in 1893 and installed on the equatorial mounting which until then had carried the Merz 12¾-in. telescope. The drum-shaped dome covering the Merz refractor was worn out, and was replaced by an Oriental-looking dome designed by Christie to contain the longer telescope. This telescope was for many years in charge of Mr. Lewis, and has been utilised for a valuable series of observations of double stars.

The provision of the photographic refractor of 13 in. with a 10-in. guiding telescope, to enable Greenwich to take part in the photographic mapping of the heavens, was sanctioned in 1888. The instrument, constructed by Sir Howard Grubb, was mounted in the 18-ft. dome over the computing rooms in 1890. The Greenwich section of the astrographic chart and catalogue and the observations of Eros for solar parallax were made with this telescope. Christie took a share in the deliberations and arrange ments for this international undertaking. He designed a micrometer for use at Greenwich which facilitated the comparison of neighbouring plates. He was also the discoverer of a very useful empirical formula connecting the magnitude of stars with the diameter of their photographic images.

The largest addition to the Observatory was commenced in 1890, but not completed until 1898. It is a cruciform building, with office rooms on the ground floor, libraries and workshop in the basement, rooms for preserving records and photographs on the upper floor. The central octagon is used as a store room, and is surmounted by a 36-ft. dome originally built to cover Lassell's 2-ft. mirror presented to the Observatory by the Misses Lassell. Before the building was completed Sir Henry Thompson generously offered to provide a 26-in. photographic refractor and a 30-in. reflector, both on the same equatorial mounting. The equatorial and the refractor were constructed by Sir Howard Grubb and the mirror by Dr. Common. The refractor was used in observations of Eros, observations of Neptune's satellites, and for various other purposes, while the reflector was used in photography of nebulæ, observations of small planets, comets, faint satellites, etc., and was instrumental in the discovery of the eighth satellite of Jupiter.

About the same time Christie designed a new altazimuth. The instrument is essentially a transit circle which can be mounted in any azimuth. It replaced Airy's altazimuth, which did not give sufficient accuracy. The new instrument usefully supplements the observations of the moon made with the transit circle.

These various extensions to the Observatory buildings cramped the space for meteorological observations, and the iron in the domes affected the magnets, which were housed in a wooden building a few yards to the north of the new observatory. A plot of ground in Greenwich Park was lent to the Admiralty by the Office of Works, where a magnetic pavilion was erected for taking absolute magnetic observations.

Christie took a good deal of interest in the observation of total eclipses. He went to Japan in 1896, to India in 1898, to Portugal in 1900, and Tunis in 1905. With the equipment arranged by him in 1896 an excellent series of large-scale photographs of the corona were taken at the eclipses of 1898, 1900, 1901, 1905, and 1914.

Christie retired from his office on his sixty-fifth birthday, October 10, 1910, with the good wishes of his staff. He maintained his interest in the Observatory, and came regularly to the annual visitation. He was also frequently at the meetings of the Royal Astronomical Society and the Royal Society, serving on the council of the Royal Society six years and on that of the Royal Astronomical Society forty-one years, being president in the years 1888–1890. Several foreign academies also accorded him honours. He received the distinction of C.B. on the occasion of Queen Victoria's Diamond Jubilee and was promoted K.C.B. in 1904.

He married in 1881 Violette Mary, daughter of Sir Alfred Hickman, of Wolverhampton. Mrs. Christie died in 1888, leaving two sons, one of whom died in childhood. His elder son, Mr. Harold Christie, lived at the Observatory until his father retired, when they went to live first at Woldingham and afterwards at Downe. Sir William was of a courteous and hospitable disposition, and would always invite some members of his staff to meet a foreign astronomer who might be visiting the Observatory. He thoroughly enjoyed astronomical conferences and eclipse expeditions for the opportunities they afforded of meeting astronomical colleagues. He acquired in these expeditions a love of sea voyages, and after his retirement made several trips abroad in the winter. In the early part of 1921 he went to Jamaica, and paid a visit to Mr. and Mrs. Pickering at the observatory of Mandeville. This year he started for Mogador a few days after meeting many of his friends at the Royal Astronomical Society Club. He was then apparently in fair health, but died on January 22, before the ship reached Gibraltar. F. W. DYSON.

DR. EMILE CARTAILHAC.

WE regret to record the death of Dr. Emile Cartailhac on November 25 at Geneva, where he had just completed a course of lectures delivered at the invitation of the University. Emile Cartailhac was born at Camarès in 1844, and for more than fifty years had been one of the dominant figures in the study of prehistoric archæology in France. His work in archæology began when the discoveries of Boucher de Perthes were still the subject of controversy, and he threw himself with characteristic ardour into the discussion. He settled early at Toulouse, and founded there in 1866 a museum of human palæontology. His success as a lecturer was immediate, and eventually led to his appointment as professor of prehistoric archæology, the only appointment of the kind in France. From 1869 onward he edited the well-known publication, "Matériaux pour servir à l'Histoire primitive et naturelle de l'Homme," with conspicuous ability; but his greatest contribution to prehistoric archæology was his synthetic study of the prehistory of France which appeared in 1889 under the title, "La France préhistorique d'après les sépultures et les monuments." This book, the first of its kind, has gone through numerous editions. Of his other writings, which were numerous, the most important were "Ages préhistoriques de l'Espagne et du Portugal," the volume dealing with the rock paintings of Altamira in the series published under the auspices of the Prince of Monaco, written in conjunction with the Abbé Breuil, and the archæological section of "Les Grottes de Grimaldi."

MR. MANSEL LONGWORTH-DAMES, whose death in his seventy-second year is reported, entered the Indian Civil Service in 1868. He served in the Punjab for twenty-eight years, with an interlude in 1879, when he was on duty with the troops in the second Afghan war. While he was stationed in the trans-Indus districts he acquired a good knowledge of the Baluch tribes and of their language; he published a Baluchi grammar and reading-book, which were for many years used by students; an account of the Baluch race, issued by the Royal Asiatic Society; and "The Popular Poetry of the Baluchis," published by the Folklore Society. He made a large collection of Buddhist art, which passed into the hands of the Berlin Museum, and he helped to arrange the Buddhist rooms of the British Museum. He was an active member of the Royal Asiatic Society, of which he was vice-president. He knew Arabic, Persian, and Portuguese well, and this knowledge he utilised in his new translation, with copious annotations, of "The Book of Duarte Barbosa," published last year by the Hakluyt Society. His death leaves a gap in the small circle of oriental scholars.

WE regret to report the death of Mr. C. F. T. HADRILL, clerk in the General Library of the British Museum (Natural History). Seized on January 12 with influenza while on his way home from the Museum, he succumbed to its effects within four days, on the evening of January 16. Mr. Hadrill first took service with the Trustees in the Copyright Office at the British Museum, Bloomsbury, in 1888. Thence he was transferred to the General Library at the South Kensington division of the Museum in 1895. Save for the period of his war service (1915 to 1919), he held his position continuously up to the day of his death. Thoroughly interested in his work, in which he took great pride, he was intimately acquainted with the books under his charge, as all who came into contact with him, whether Museum officials, or students, or casual visitors, soon realised; and his services, always most willingly, obligingly, and efficiently rendered, were consequently in perpetual demand. His loss will be felt as a personal one by a large circle of scientific workers, including those connected with the "Zoological Record," for which he was one of the researchers.

Notes.

THE Bakerian lecture of the Royal Society will be delivered on March 9 by Prof. T. R. Merton and Mr. S. Barratt on "The Spectrum of Hydrogen."

THE fifth Silvanus Thompson memorial lecture of the Röntgen Society will be delivered by Sir Oliver Lodge at the Institution of Electrical Engineers on Tuesday, March 21.

AT a meeting of various sections of the welding industry held on January 26 it was resolved that a new society, to be known as the Institution of Welding Engineers, be formed. The society will embrace all systems of welding, and anyone who is interested in welding and allied industries will be eligible for membership. The hon. secretary (*pro tem.*) is Mr. C. Raggett, and the temporary home of the new institution is at 30 Red Lion Square, London, W.C.1.

INFORMATION has reached us from Mr. D. H. Cain, 13 Duke Street, St. James's, S.W.1, that an English company, known as Radium Ore Mines, Ltd., is to re-open the Tolgarrick radium mine situated near Truro. According to this announcement, the mine was abandoned at the outbreak of the war, but is already installed with all the plant necessary for immediate resumption of work. Two rich lodes of uranium ore are to be worked, and the intention is to treat the ore on the spot. The development of radium spas in this connection is also foreshadowed.

TWO noteworthy prizes for the discovery of a cure for cancer have recently been announced, namely, one by Lord Atholstan of 100,000 dollars, and the other by Sir William Veno of 10,000*l*. Both prizes are limited to students and graduates of recognised universities, and they will be awarded to the first investigator who within the next five years succeeds in discovering a non-surgical effective cure for cancer. The awards will be made on the decision of the Royal Colleges of Physicians and Surgeons in London.

AT the monthly meeting of the Zoological Society of London, held on January 18, the secretary reported that seventy-nine additions had been made to the society's menagerie during the month—thirty by presentation, thirty-nine deposited, and ten by purchase. The most noteworthy addition to the collections is a pair of lions from India, presented by H.M. the King. The number of visitors to the gardens during 1921 was 1,386,745, and the receipts for admission amounted to 46,509*l*. Four hundred and seven new fellows were elected to the society during the year, and while this number is 123 fewer than in the previous year, it is 95 above the average for the last ten years. These figures are eloquent of the popularity of this institution.

A MOVEMENT has been set on foot to erect a fitting memorial to the great sanitarian, William Crawford Gorgas, through whose labours it became possible to complete the construction of the Panama Canal. Inaugurated by Dr. Belisario Porras, the President of the Republic of Panama, the scheme aims at the erection of a hospital and laboratory for tropical and preventive medicine. The Panama Government has provided a site, a building, and modern equipment valued at half a million dollars, as well as the use of the two-million-dollar Santo Tomas Hospital, which is just being completed. It is hoped to increase the initial sum available by another four and a half million dollars by means of contributions from the public and the Governments which have benefited from the work of Gorgas. A provisional board of directors for the United States has been appointed. The laboratories to be built will resemble the Pan-American buildings in Washington, while Dr. R. P. Strong, of the Harvard School of Tropical Medicine, is to be the scientific director of the memorial.

SHORTLY after the retirement of Prof. P. F. Frankland from the Mason chair of physics in the University of Birmingham a fund was opened with the object of providing some permanent memorial of his work in the University. The money subscribed was devoted in the first place to a portrait of Prof. Frankland (painted by Mr. Bernard Munns), which now hangs in the great hall of the University at Edgbaston. The balance of the fund has been applied to the institution of a Frankland medal, which, together with a prize of books, is to be presented annually to the best student in practical chemistry. The medal is of bronze, bearing on the obverse a profile portrait of Prof. Frankland, and on the reverse the arms of the University. A handsome book-plate has also been designed to be placed in the prize-books. The name of this distinguished chemist will thus be kept green in the memory of future generations of students, and the prize will doubtless act as a stimulus to the attainment of excellence in the practical study of chemistry, on the importance of which Prof. Frankland so wisely insisted.

THE Gypsy Lore Society, founded in 1888 by Mr. David MacRitchie to promote the study of the language, history, ethnology, and folk-lore of the gypsy race, continued its useful career until its publications were suspended in 1892. After fifteen years it was revived under the direction of Mr. R. A. Scott Macfie, but its work again ceased owing to the war in 1914. We are glad to learn that the society has now been revived again under the presidency of Mr. W. Ferguson, with Mr. T. W. Thompson as honorary secretary. The address of the honorary treasurer, to whom the subscription of 1*l*. per annum is payable, is 7 Macdonald Road, Friern Barnet, London, N.11. The society in its new form has received the support of several eminent scholars interested in the subject, and many valuable contributions have been promised. The study of the gypsies is to be commended from many points of view and we trust that the society will receive generous support and meet with the success which it deserves.

IN 1821 some residents of New South Wales of a scientific turn of mind founded the Philosophical Society of Australasia, the first scientific society to be formed in Australia. The society did not continue its meetings for long, and while other societies devoted to agriculture, horticulture, botany, etc., were formed, it was not until 1850 that a society for general science known as the Australian Philosophical Society, with Sir Thomas Brisbane as president, came again into existence. Only two members of the original society were also members of the 1850 society, namely, Alexander Berry and Dr. H. G. Douglass, the latter of whom was honorary secretary of both societies. In 1855 the name was changed to the Philosophical Society of New South Wales, and in 1866 this name gave place to that of the Royal Society of New South Wales, which it still bears. To commemorate the centenary of the foundation of the parent society, members of the Royal Society of New South Wales visited Kurnell on December 10 last, where the president and members of the original society had erected a brass tablet in memory of the landing of "James Cook and Joseph Banks."

INFLUENZA in London had very appreciably decreased according to the deaths given in the Registrar-General's return for the week ending January 21; the decrease compared with the preceding week was 108. In the ninety-six great towns of England and Wales the deaths had increased in the corresponding period by 164, but there seems a good prospect that the improvement shown in London will extend to other parts of England. Of the total deaths from influenza in London during the week 56 per cent. occurred between the ages of forty-five and seventy-five. In London there have been with the present attack thirty-one epidemics since 1890, considering a well-established 20 or more deaths per week as epidemic. The only years without an epidemic are 1896 and 1901, and of the thirty epidemics preceding the present, twenty-seven have occurred in March, twenty-four in February, eighteen in April, and seventeen in January. Not one has been existent in September, only one in August, two in July and October, and three in June. The complaint is essentially epidemic in winter and spring, but there seems little

indication of it being helped or hindered by spells of heat or cold.

ENGLISH engineers are glad that it is highly probable that the contract for the electrification of the South African Railway between Pietermaritzburg and Glencoe will be given to the Metropolitan-Vickers Co., of Manchester. In the early days of the electrical industry in South Africa German competition was severely felt, but much of the foreign-made plant then purchased has given great trouble to the users, due not only to faulty design, but also to the fact that it got much too hot at full load. English machines were found to be more desirable. The contract will involve the construction of seventy locomotives. The line carries very heavy mineral traffic on its way to the coast in Natal and goes through a hilly district. It is, therefore, very suitable for electric traction, as regenerative braking can be used on the descending grades. In addition to pumping back into the line most of the potential energy lost, it obviates all the wear and tear on wheels and brake-shoes inevitable with steam traction. Each of the locomotives will be equipped with four large electric motors, and the construction of these and the necessary control gear will, unless the unforeseen happens, provide employment for many workpeople in Sheffield and Manchester.

THE thirteenth meeting of the International Geological Congress is to be held in Brussels on August 10–19. Excursions to places of geological interest in Belgium will be held before the congress, on August 1–9, and afterwards from August 21–September 3. An interesting programme of geological discussions on subjects including tectonics, the geology of the Carboniferous system and of petroleum, and the geology of Africa—a subject to which Belgian geologists have contributed greatly. The committee of organisation has decided not to admit ". . . nationals of those countries lately at war, in defiance of Treaty obligations, with Belgium "—a phrase which only an international lawyer could confidently interpret. It might be intended to exclude Germans only, but might admit of considerable extension. The admission of Germans and Austrians to the social functions of the congress might be reasonably regarded as premature, but their complete exclusion from an international scientific congress will be regretted by many British geologists. The president of the organising committee, who will naturally be president of the congress, is M. J. Lebacqz, Director-General of Mines, and president of the Geological Council in Belgium. The secretary is M. Renier, the head of the Geological Survey of Belgium. There will be five excursions before the congress to examine respectively the central and eastern districts, the Tertiary beds, the Devonian, and building materials. There will also be ten local excursions, most of which are for a single day, during the congress. Five excursions after the congress will be devoted to the study of the Cretaceous and Tertiary rocks near Mons, the metamorphic rocks at Bastogne, the Palæozoic tectonics, the Carboniferous limestones, and the Westphalian. These excursions vary from four to twelve days.

THE Secretary of State for Air, Capt. Guest, received a deputation from the council of the Royal Aeronautical Society on January 17 and heard views for safeguarding the applied scientific research of the Air Ministry. Attention was directed to the danger of dealing exclusively with the needs of the moment, particularly by routine methods, and to the fact that present and future economy called for systematic inquiry on scientific principles. The high insurance rates required to cover aviation risks and the loss of the airship R38 are instances which will occur to readers of NATURE as matters needing more than passing attention. The deputation consisted of Col. M. O'Gorman (chairman), Prof. L. Bairstow, Sir Mackenzie Chalmers, Prof. B. M. Jones, and Lt.-Col. A. Ogilvie, and represented the council of the Royal Aeronautical Society, except that Service members felt that their appointments debarred them from expressing an opinion. A marked distinction was made between "applied scientific research" and "*ad hoc* experiments," and it was stated that experience showed that the latter take precedence and tend to the extinction of research on the ground of urgency when both are under a common direction. The cessation of airship research both on the full scale and in the laboratory and the proposal to close the Aerodynamics Department of the National Physical Laboratory (happily not being fully pressed) indicate how serious has been the position in the past year. The deputation suggested that the remedy lay in the appointment of a scientifically trained head of a department specially devoted to applied scientific research. As applied to a new science the difficulties are great, but it is understood that the proposals are receiving the serious and sympathetic consideration of the Secretary of State for Air.

THE report of the "Wireless" Telegraphy Commission which has just been issued is of value, as it represents the reasoned and deliberate judgment of three well-known experts. In his preface Dr. Eccles comments on the "severely technical" nature of the report, but as the terms of reference definitely ask for advice on the preparation of specifications for machinery and apparatus this was unavoidable. The Commission is to be congratulated on the thoroughness with which it has done its work. As in all engineering projects, however, unless the scheme is begun at once further discoveries may make it advisable to alter appreciably the detailed specifications. It recommends that a radio-chain be established, none of the steps being greater than about 2000 miles. The radio-telegraphic energy is to be generated by thermionic valves. The first step is to be from Leafield to Cairo, which the Post Office will shortly operate by means of Poulsen arcs. Then valve stations will be erected at Poona, Singapore, Hong Kong, and in Australia at either Port Darwin or Perth. Valve stations would also connect England and Canada. The stations are to be capable of delivering at least 120 kilowatts to the antenna. They will be larger, therefore, than the Carnarvon station of the Marconi Company. It has been found that there is a considerable loss of

energy due to the induced currents in the earth under the antennæ. The Commission therefore advises that efficient earth-screens made of grids of copper wire be used at all the chain stations. It is suggested that the Marconi Company be invited to tender for earth-screens, antenna tuning coils, and thermionic-valve sets. It also suggests that if their tender be not acceptable, suitable plant could be designed by the Commission after the conclusion of the work now being undertaken at Horsea.

THE last annual report from the Field Museum of Natural History at Chicago deals with the highly successful removal of the collections from the building in Jackson Park to a new building in Grant Park. The Section of Plant Reproduction continued to turn out those beautiful models of vegetable structure on which we have commented in previous years. In addition to several fruits and flowers, the reproductions include the green algæ, Œdogonium and Ulothrix, enlarged tip of a frond of the alga, *Bryopsis plumosa*, a cotton plant, and a cycad, *Zamia floridana*. Another reproduction illustrated, but not otherwise mentioned, in this report is a restoration of the New Zealand moa, 13 ft. high. We do not know which species of Dinornis this professes to represent, but it seems to have an abnormal number of cervical vertebræ, a mammalian back, and pantomime legs.

IN "La Cité des Termites" Dr. J. Feytaud gives a very interesting account of the social habits of *Leucotermes lucifugus*, Rossi. The author has had excellent opportunities to study this species of white ant (one of the two species of the family found in Europe) at first hand in the south-west of France, and he has made good use of them. The brochure contains one of the most complete studies of the life and habits of the termites that we have. Much of the information has appeared in scientific journals, but now that the author has brought his studies together into one volume the intricate and elaborate social life that exists amongst termites should become more widely known. A chapter is devoted to the ravages and means of destruction of termites.

SOME interesting anthropological data relating to the Pitcairn Islanders, the descendants of the mutineers of the *Bounty*, are contained in an appendix by Dr. D. Colquhoun, of Dunedin, New Zealand, to a report on a visit paid in June last to Pitcairn Island by Sir Cecil Rodwell, High Commissioner of the Western Pacific (Colonial Reports—Miscellaneous: No. 93). The present inhabitants, who number 174, are the descendants of forty of the islanders who, in 1859, returned to Pitcairn from Norfolk Island, whither the whole population of 190 had migrated in 1856. Dr. Colquhoun describes the islanders as lighter in complexion than pure Maoris, and says many would pass for southern Europeans. The hair is generally dark and straight, although one individual had the frizzy hair, dark skin, and thick lips of a Melanesian type, and two children had fair hair and blue-grey eyes. Generally the eyes are dark brown, rarely bluish-grey. All the islanders are dolichocephalic. No stigmata of the degeneration through in-breeding, which was anticipated from the evidence afforded by Admiral Palliser's visit to the island in 1898, were observed, and the island is singularly free from disease. Copies of the report may be obtained from H.M. Stationery Office, Imperial House, Kingsway, W.C., price 10*d*.

RÉSEAU MONDIALE, 1914, has recently been published by the Meteorological Office of the Air Ministry. The preface to the work is written by Sir Napier Shaw. The present volume completes five years of the publication, 1910 to 1914, which will afford some idea of the value of the compilation of meteorological data for the whole globe which it has been the ambition of meteorologists to achieve for a long time past. Data for 1914 were not obtainable until some time after the war, and information for many of the Siberian stations is still lacking. The number of stations recorded for the present volume is 392. Two stations are chosen for each ten-degree square, and the results are given for each month and for the year. For barometric pressure the mean is shown with the difference from the normal. For temperature the mean maximum and mean minimum values are tabulated with the mean of the maximum and minimum and the difference from the normal, together with the absolute maximum and absolute minimum temperatures experienced. For rainfall the total precipitation is given and the difference from the normal.

THE report of a general discussion on the physics and chemistry of colloids, held jointly by the Faraday Society and the Physical Society of London, has been issued by the Stationery Office at the price of 2*s*. 6*d*. It includes nearly thirty formal papers on colloids, in addition to the discussions arising therefrom. Special attention may be directed to the brilliantly lucid "Survey of the Physics and Chemistry of Colloids," by Prof. Svedberg, of Upsala, with which the proceedings were opened. The essential outlines have been drawn with a clearness and firmness of touch that has never before been equalled, whilst the bibliography at the end of the paper shows where the details required to complete the picture may be found.

THE demand for very penetrating X-rays for purposes of medical therapy has led to the construction of high-tension apparatus capable of giving a continuous output for several hours of current at an alternative spark-gap up to about 18 in. This has caused considerable modifications in the design of both induction coils and interrupterless transformers. A circular on "Deep Therapy Apparatus, Section 2b," issued by Messrs. Newton and Wright, Ltd., gives a description of an induction coil designed for this type of work. The coil really consists of two symmetrical coils mounted side by side, the whole being immersed in oil; this latter avoids breakdowns due to insulation troubles produced by the high-tension discharges in the air in the interior of the coil. A useful feature of the double-

coil design is that it allows the milli-ampere meter to be inserted at the mid-point, which is at zero potential, and hence the instrument can be brought to an ordinary low-tension switchboard.

AN account of the discussion on the future of geometrical optics which took place at the Cambridge meeting of the Optical Society in May last is given in part 5 of the Transactions of the society for the present session. On the whole, the representatives of the manufacturers were in favour of retaining the step-by-step trigonometrical method of tracing rays through the system under design in order to get rid of aberrations rather than changing to the analytical methods, which give the aberrations of the first order in terms of a certain quartic in the magnification and those of the second order in terms of

$$M(1+AM)/(1+BM),$$

where A and B are constants and M is the square of the inclination of the ray to the axis. It was, however, suggested that some attempt should be made by mathematicians to reduce the complexity of the formulæ involved by bringing the subject into line with the wave theory. It was pointed out that the British optical trade must in the next four or five years improve its optical designs if it is to be able in the future to sell its products against the better designed articles offered by manufacturers of other countries.

A LIST of American research chemicals has been issued as No. 23 of the Reprint and Circular Series of the National Research Council, Washington. The list includes biological stains and indicators, and includes a very large number of fine chemicals. The number is larger than that in the corresponding list of British research chemicals, issued by the Association of British Chemical Manufacturers, but the latter is incomplete, and although not dated, was issued some time before the American list. The American list also includes many very simple derivatives, such as acetyl and benzoyl compounds, which swells its bulk. One noticeable feature of the American list is that it includes a large number of rarer inorganic chemicals likely to be required for research purposes, whilst the British list is largely made up of organic chemicals. It is desirable that a new and more complete edition of the latter should be issued as soon as possible, and that requirements in inorganic, as well as organic, chemicals should be kept in mind.

THE provision of a works laboratory is now recognised as an essential part of the organisation of any large engineering firm. The equipment will, of course, depend upon the kind of work carried out by the firm. The laboratory at the Bedford works of Messrs. W. H. Allen and Sons, Ltd., forms the subject of an illustrated article in *Engineering* for January 13, and its equipment may be taken as an excellent example of what is required by a firm manufacturing a wide range of high-grade mechanical engineering products. There is a main mechanical testing-room, a chemical laboratory with balance-room and stores, a recalescence room, a photomicrographic room, dark room, and office. The mechanical testing equipment includes a Brinell hardness machine, a Sankey autographic bending machine, machines for repeated impact testing of the Eden-Foster and Stanton types, an Izod impact machine, a 30-ton Buckton machine with a Ewing extensometer, and a Shore hardness testing machine. The same room contains a number of machine tools for the preparation of specimens. The chemical laboratory has also a very complete equipment; the recalescence furnace is a modification of the one in use in the National Physical Laboratory. It is perhaps unnecessary to add that this laboratory has exercised a very effective control over the quality of the firm's products.

AN introductory address to his lectures at University College on waterways, harbours, and docks was delivered by Dr. Brysson Cunningham on January 24. The great value of the ocean as an international waterway and the facilities it affords for traffic, with far fewer difficulties than in the case of land routes, were emphasised. Before the war railway construction in England had cost something more than 50,000*l.* per mile, including expenses of promotion, while in the United States the cost averaged only about one-fifth of this sum; the outlay for track formation proper was about 5000*l.* or 6000*l.* per mile. In both cases there is, in addition, the expense of maintenance, whereas in a waterway on the high seas there is neither cost of construction nor of upkeep. This is true, though in a lesser degree, of the rivers and inland waterways. Dr. Cunningham also discussed ports, pointing out that few modern ports have kept pace with the requirements of the naval architect in regard to ship design. Rational developments in shipbuilding are impeded by lack of depth of water at the principal ports and in the Suez Canal. The following table shows the actual rate of expansion in the dimensions of vessels in the mercantile marine during the past forty years:—

Average dimensions of the twenty largest steamships in each of the years mentioned.

	1881. Feet.	1891. Feet.	1901. Feet.	1911. Feet.	1921. Feet.
Length.. ..	460	507·0	599	703·5	735·0
Breadth ..	45	54·5	65	73·6	82·5
Depth	30	31·0	39	47·7	51·0
Loaded draught	24	27·0	32	32·5	34·0
Tonnage ..	4,900	6,980	14,150	21,600	31,550

Sir John Biles has claimed that it would be economical to construct vessels up to 1000 ft. in length provided it were possible to give them the appropriate draught of 57 ft., but there are very few ports in the world which could receive a vessel of this draught. Forty feet is the extreme limit of draught which is available at the present day for sea-going vessels.

IN the general article on "Agriculture at the British Association" in NATURE of January 5, p. 25, it was stated that "Mr. M. M. Monie gave an account of a photographic survey of soils . . . the method he proposes, while of limited use by itself, should have a useful place in soil-survey work." Mr. Monie writes to say that his remarks were "that a photographic

record of topography, soil profiles, and soil types in the field was a most useful section of my soil survey, forming about 10 per cent. of the work." As an illustration of the value of the method, he showed a telephotograph of an area covered by mounds of fluvio-glacial sands and gravels. Mr. Monie also states that the field methods he has worked out for the West of Scotland can easily be applied to give useful results over most areas.

THE reviewer of the translation of Prof. le Blanc's "Text-book of Electrochemistry" in last week's NATURE, p. 101, remarked that though the title-page bore the date 1920, he could find no references later than 1907. It has been pointed out to us, however, that the translation, as stated on the title-page, is of the fourth German edition, and that the author's preface to this edition, dated 1906, is printed in the volume. The translators state in their preface that the work is a translation of this edition, and at the back of the title-page are printed the words "Published March, 1907." It was not suggested by the publishers, therefore, that the work was anything more than the fourth edition; the date on the title-page was merely that of the current reprint.

REFERRING to the notice in NATURE of January 12, p. 59, of the new petrological microscope manufactured by Messrs. R. and J. Beck, the firm wishes it to be known that the left-hand slow-motion milled head is provided with graduations each of which represents 0·01 of a millimetre.

MESSRS. BOWES AND BOWES, Cambridge, have just issued a MS. list of recent books dealing with mathematics on sale by them, and another of works in the German language. Messrs. H. K. Lewis and Co., Ltd., 136 Gower Street, W.C.1, have sent to us a list of the new books and new editions added to their Medical and Scientific Library during October–December. These lists and that of "Recent Scientific and Technical Books" issued with NATURE of January 26 should make it possible for readers to keep abreast of current scientific literature.

MESSRS. CHAPMAN AND HALL, LTD., are about to publish a book by Dr. G. W. C. Kaye entitled "Industrial Applications of X-rays," which aims at presenting in language not too technical the various uses to which the rays can be usefully applied in commercial undertakings. Another book in the announcements list of the same publishers is "Mechanical Testing," by R. G. Batson and J. H. Hyde, 2 vols. Vol. 1, which will deal with the testing of materials, is expected to be published in February, and vol. 2, treating of the testing of apparatus, either in May or June.

Our Astronomical Column.

THE TOTAL SOLAR ECLIPSE OF NEXT SEPTEMBER.—The Greenwich Expedition which is being sent to Christmas Island for this eclipse, consisting of Messrs. H. Spencer Jones and P. J. Melotte (the former being accompanied by his wife), sailed from Liverpool on January 28 in the s.s. *Mentor* (Blue Funnel Line). It is hoped by May to have the instruments ready for observation; the apparatus taken weighed 4 tons, including the 13-in. astrographic equatorial, which will be used for stellar photometry, to connect the magnitude scales of the northern and southern hemispheres, in addition to the eclipse programme, which is simply a repetition of the testing of the Einstein light-shift. The stars are fainter than those of the 1919 eclipse, but the replacement of the cœlostat by an equatorial should bring a great gain in definition.

The *Times* of January 27 makes the welcome announcement that the Commonwealth Government will put a warship at the disposal of the parties visiting Wollal, Western Australia; these include a large party from the Lick Observatory, also parties from Toronto and New Zealand and some Australian astronomers. This will be of great assistance to the parties, but will not remove all their difficulties, as there is no harbour in the neighbourhood, and ships have to anchor some miles out, and land passengers and goods by boats through a surf that is often heavy.

Mr. J. Evershed, director of Kodaikanal Observatory, hopes to observe the eclipse from the Maldive Islands.

THE PLEIADES.—Lick Obs. Bull. No. 333 contains an important study of this cluster by Mr. Robert Trumpler. The stars belonging to it are distinguished from the background stars by their proper motion; Boss's value for the bright stars is 5·4″ per century in position angle 157·9°. A list is given of 246 stars, of magnitudes between 2·8 and 15·2, that are concluded to be members of the cluster; this conclusion is supported in the case of the fainter stars by the fact that the average motion of stars of these magnitudes is much smaller. The conclusion is strengthened by an examination of spectral types; these are found directly for the stars brighter than magnitude 11, and inferred from the colour-index for the fainter ones. On plotting spectral class against magnitude a smooth curve is found, which descends less steeply in the middle portion than at the ends; it is interesting to note that a practically identical curve was reached at Greenwich by Messrs. Davidson and Martin on plotting effective wave-length against spectral type for stars in the Greenwich astrographic zone.

Inferring the absolute magnitudes for each spectral type from stars of known parallax, the parallax 0·008″ is found for the Pleiades. The hypothetical parallax deduced from the binaries in the cluster is 0·010″, while Hertzsprung and Hartmann found 0·014″ from the parallactic motion of the group. It is inferred that the round value of 100 parsecs, or 320 light-years, is close to the true distance. One very interesting fact is that the red and yellow stars in the cluster are dwarfs, the only giants being those of type B and perhaps a few of type A. It will be remembered that on Russell's theory the B type is the latest of the giant stages, so that the cluster would seem to be in its old age. Examination of the binary stars supports Aitken's conclusion that stars of considerable mass are more likely to divide. Another point noted is the deficiency of stars of type F, suggesting that this may be a short-lived stage. The average star density of the whole group is about ten times that in the sun's neighbourhood. That in the centre of the group is still greater. Correcting for the sun's motion, the speed of the group is 9 km./sec.

Chemistry at the British Association.

THE attendance at Section B during the Edinburgh meeting of the British Association was exceptionally large, and was well maintained throughout, so that, although the meeting-place of the section was the commodious chemistry lecture-room of the University, it was sometimes impossible to find accommodation for all those who wished to hear the discussions. The joint meetings with other sections were very popular, and the practice adopted by the section in recent years of having only a small number of papers at each session led to the interest in the proceedings being well maintained owing to the full discussion of important papers.

The programme contained a number of contributions to the subject of chemistry in its bearing on the problems of animal and vegetable life. The joint discussion with the Section of Physiology on oxidations in living tissues has already been reported (NATURE, November 10, 1921, p. 353). The president's address on "The Laboratory of the Living Organism" (NATURE, October 20, 1921, p. 243) was one of the most successful features of the meeting. Dr. Forster omitted the more technical portions of his printed address, and delivered an exceptionally lucid lecture which must have made clear to many students of chemistry who had not previously studied recent work in biochemistry both the importance of the subject and the fascinating character of the reactions which take place at atmospheric temperatures and without the presence of energetic condensing agents in the living organism. The paper by Prof. Robinson, which followed on the presidential address, elaborated one aspect of the same subject, the author indicating the reactions by means of which flavones, anthocyans, and other compounds which occur naturally as plant pigments may be derived from carbohydrates by condensations which are capable of occurring at the atmospheric temperature.

Profs. Baly and Heilbron and Mr. Barker dealt with the synthesis of formaldehyde and carbohydrates from carbon dioxide and water under the influence of light. These reactions are brought about by light of very short wave-length, but in the presence of certain coloured substances, which act as photo-catalysts, they can take place in light of a lower frequency. Chlorophyll, on account of its optical properties, is an ideal photo-catalyst for both stages of the carbohydrate synthesis. Dr. E. J. Russell pointed out that although magnesium is an essential constituent of chlorophyll, the addition of magnesium salts to the soil does not increase the amount of photo-synthesis in plants, as does the addition of that of potassium salts. He also remarked that the first product of carbohydrate synthesis in the plant is cane-sugar, which is then hydrolysed. The formaldehyde hypothesis, proposed fifty years ago by von Baeyer, is thus still a matter of controversy. A paper by Prof. Jaeger, of Groningen, had to be taken as read on account of the time occupied by the preceding discussions. In this the author showed that the decomposition of simple organic acids and their salts in solution by ultra-violet light was in a high degree dependent on the presence of catalysts, the results thus having a bearing on the question of photo-synthesis.

Another group of papers dealt with physical chemistry. The discussion on the structure of molecules, held jointly with Section A, was highly successful, and has already been reported (NATURE, October 13, 1921, p. 218). Theories of atomic structure, which have hitherto been the special concern of the physicist, are now invoked to explain chemical phenomena, especially those connected with valency; hence the new interest taken by chemists in the subject. Three papers on surface tension were also communicated to the section. Prof. Jaeger described the experimental methods by which he has been able to measure the surface tension of liquids between the temperatures of $-80°$ and $+1625°$ C. The method consists in determining the pressure needed to cause a gas bubble to burst when emerging from a platinum capillary immersed to a known depth in the liquid. The results obtained from molten salts indicate that if Eötvös's relations be assumed to hold, these liquids must be highly associated, but that the validity of the assumption is doubtful. The method is not applicable to metals, as it is necessary that the liquid should wet the platinum. Mr. Cosmo Johns described his observations on the surface of freely flowing liquid steel. The optical properties of such a surface indicate that it is free from oxide, and the author has previously explained this fact as being due to an atmosphere of iron vapour. Evidence for such an atmosphere was now given, the particles collected from the atmosphere near to the outlet of the furnace being relatively richer in manganese (the more volatile metal). The behaviour of these fine particles under the influence of gravity and of a magnetic field was also described. Prof. Desch gave an account of measurements of foam cells in soap and other foams. The most frequently occurring figure proved to be the pentagonal dodecahedron, slightly distorted. An examination of the crystal grains of several metals proved that these grains had the form of foam cells, graphs showing the frequency of occurrence of similar faces coinciding completely, from which the conclusion was drawn that the grain boundaries are determined by surface tension.

A question of national interest was raised by the paper on the modern dye industry contributed by Prof. H. E. Fierz, of Zürich. The main argument of the paper was that the capacity for production of dyes now largely exceeded the demand, and that it was impossible for the dye industry to remain self-contained. The intermediate and final products lent themselves readily to conversion into pharmaceutical and photographic chemicals, technical colloids (viscose, bakelite, etc.), and similar products. The chemical industry must therefore be regarded as a whole, and a new organisation was necessary.

A discussion on atmospheric pollution by smoke concluded the session. Dr. Owens described the apparatus used by the Advisory Committee, and showed records taken at various stations in London, whilst Mr. W. Thomson described the somewhat different apparatus used in Manchester, and exhibited a long series of records from that town. The principal difference noticed was the regular occurrence of a weekly maximum on Monday in the smoke pollution of Manchester, which was never observed in London. That the clearness of the atmosphere during the coal dispute of 1921 was due to the absence of smoke, and not merely to the exceptionally fine weather, was proved by comparing the sunshine records from different parts of the same town. The report of the Fuel Economy Committee, which had a bearing on the same subject, was received, but was not discussed by the section.

The sittings for the reading and discussion of

papers were confined to the mornings, but the section was also occupied in the afternoons. Prof. Barger gave a demonstration in the University of methods for the micro-analysis of compounds containing carbon, hydrogen, and nitrogen, whilst other afternoons were devoted to excursions. Much interest was taken by members in the inspection of the new University chemical laboratories at Liberton, which are arranged as single-story buildings with a central store, the arrangement being convenient and economical, whilst allowing the greatest possible freedom when alterations have to be made. Other visits included the Heriot-Watt College, Messrs. Younger's brewery, the North-British Rubber Co.'s mills, Pumpherstone Oil Works, and the pharmaceutical works of Messrs. Duncan, Flockhart and Co. The rubber works and the shale oil works proved to be specially attractive to members.

Rehtia, the Venetic Goddess of Healing.

AT a meeting of the Royal Anthropological Institute held on January 11 Mr. J. Whatmough read a paper on "Rehtia, the Venetic Goddess of Healing." The Venetic goddess Rehtia (or, as her name might have appeared in Latin, *Rectia*), for whom an apt Greek parallel in name and functions, as well as in characteristic votive offerings, has been found in the Spartan Artemis Orthia, was worshipped not far from the modern town of Este (15 miles south-west of Padua). Her cult, known perhaps to a handful of scholars all told, bears, according to Mr. Whatmough's new explanation of an important group of her offerings, a close likeness to that of the Italic Juno as the protecting goddess of women, with whom Rehtia should be compared rather than, as previously, with the Etruscan Nortia. The group of inscribed votive offerings in question—the so-called "nails" and "wedges"—now better regarded as pins with pendant axe-shaped talismans of a well-known Hallstatt type, was made all but exclusively by women, as the dedicatory inscriptions show. From the shrine of Orthia at Sparta come large numbers of bronze pins, comparable with the Venetic pins which, it is suggested, were given, originally at all events, by women as votive offerings before (or just after) childbirth.

Just as Orthia is expressly described as "The Restorer," or as a healing deity who "restored women to health after childbirth and preserved their infants" (and as such was associated at Epidaurus with Asclepius *Orthios*), so Rehtia is called *Sanatis*, "the Healer," and the word *akeo* which appears on another class of her votive offerings seems also to refer to her healing functions (compare Greek *ἀκέομαι*). Women paying their vows to Juno Lucina at Rome had to loosen all knots and fastenings about their clothing and take down their hair; it would then be appropriate for them to offer their dress- and hair-pins (or votive objects copied from these) to the goddess. The miniature talismanic axes would imply a magical purpose, the safeguarding of mother and child during gestation and after delivery. With *Sanatis* and *akeo* we can compare such epithets of Juno as Lucina, Februa (Sanatis especially in this connection), Fluonia, and Sospes. It would be a simple step in the development of the goddess (as of Juno) for her to become the saving goddess of both sexes and all classes. The chief duty, however, within her purview would be to maintain or to restore physical health—the soundness, fitness, *rightness* of the body.

Livy, describing events which occurred in 302 B.C. (nearly a century before the beginning of the romanisation of Transpadane Gaul), refers to a temple in the country of the Veneti not far from Padua which he ascribes to Juno; Strabo calls it a temple of the Argive Hera. Most probably the ancient Veneti worshipped a great goddess Rehtia whose functions were similar to those of the Italic Juno and the Argive Hera, so that later observers like Livy and Strabo, familiar with both the more famous Roman and Greek cults, noted the similarities between these and the Venetic cult, and regarded them as essentially the same, if, indeed, we are not further to conclude that with the extension of Greek and Roman religions and civilisations an actual identification had taken place.

Mr. Peake, in discussing Mr. Whatmough's theory, agreed that the bronze objects were not "nails" and "wedges," but pins, though possibly cloak-pins rather than hair-pins, and "axes." The use of the long cloak-pin in the Iron age, when for practical purposes the pin had developed into the fibula, was possibly to be explained by religious conservatism. He also suggested that possibly the wedge-shaped "axe" talisman had developed from the anthropomorphic form of talisman rather than the latter from the former. A third possibility was that they were merely ornaments made to jingle, similar to those common among all horse-loving peoples such as were the invaders of Italy from the north in the Late Bronze and Early Iron ages. While Rehtia could doubtless be equated with Orthia and with Juno, question arose whether the cult was Mediterranean. The Argive Hera is markedly Mediterranean, but Orthia belongs definitely to the northern peoples, as probably did Rehtia. No doubt there had been amalgamation, but the more distinctive features were northern. In their culture some things point to the Veneti being northerners, and probably they were one of the waves of immigration, evidence of the earliest of which was found at Bologna.

British Mycology.

THE Transactions for 1920 of the British Mycological Society published in July last are evidence of the increasing activities of the group of botanists whose work is amongst the fungi. The presidential address by Mr. Petch deals with fungi parasitic on scale-insects, and includes an historical account of the growth of knowledge since the first record of a fungus growing parasitically on a scale-insect was made by Desmazières in 1848 at Caen, in Normandy. The list is now a long one, and will doubtless be further extended; and though the majority of scale-insect fungi are tropical, there is some work to be done on them in the British Isles. In the tropics enormous destruction of scale-insects is effected by these fungi, and, as some of the scale-insects are serious pests of economic plants, the suggestion naturally arose that the pests might be controlled by means of the entomogenous fungi. A special investigation was undertaken by the United States Bureau of Entomology in Florida, but the results agree with those of other experiments, and Mr. Petch affirms that after thirty years' trial there is no instance of the successful control of any

insect by means of fungus-parasites. Prof. A. H. R. Buller describes the mechanism by means of which the common mould-fungus, Pilobolus, is able to shoot its spore-case, containing many thousands of spores, a distance of several feet. Sunlight striking obliquely on the protoplasm of the cell beneath the spore-case gives rise to a stimulus resulting in a movement which places the axis of the stalk on which the spore-case is borne in the line of the light-ray. The fungus may be described as having an optical sense-organ or simple eye which it uses for laying its gun in a definite direction. Pilobolus lives in fields on the dung of herbivorous animals, and by directing its guns towards the source of brightest light is enabled to shoot its sporangia into open spaces on to grass and other herbage. Herbivorous animals eat grass and sporangia together, and the spores are passed unharmed in the solid excreta in which they germinate.

Mr. F. T. Brooks discusses the inheritance of disease-resistance in plants in the light of recent Mendelian work. It has been shown that susceptibility and immunity to yellow rust disease among varieties of wheat are genetic factors operating in a Mendelian way, and Mr. Brooks suggests that resistance and susceptibility of potatoes to wart disease may afford a similar case. He points out, however, that we are very much in the dark as to what is the essential factor conferring resistance, and the possibility that changed conditions of environment may break down to some extent the resistance-powers of the host as regards certain diseases. There are also short papers of local interest and on new or rare British species. Mr. Ramsbottom explains the "Californian bees," the identity of which has been puzzling folk during the past two years. The organism is the well-known ginger-beer plant which was investigated by the late Prof. Marshall Ward, and consists of two organisms, a yeast and a bacterium, living in symbiosis and causing alcoholic fermentation in a sugary solution.

University and Educational Intelligence.

CAMBRIDGE.—A special Syndicate appointed to consider possible alterations in the regulations for the Mathematical and Natural Sciences Tripos with the object of facilitating the acquisition by candidates in one subject of a knowledge of the other has reported in favour of the addition of mathematics to the list of subjects for the Natural Sciences Tripos, Part I. Arrangements are proposed by which part of the papers set in the Mathematical Tripos, Part I., may be used as papers in the Natural Sciences Tripos, Part I. The reform will be of considerable assistance to students reading physics, physical chemistry, and chemistry.

LONDON.—The Senate has received with great satisfaction a communication from the executors of the late Sir Ratan Tata intimating their continuance for a further period of five years of his benefaction of 1400*l.* a year to the Ratan Tata Foundation. This will henceforth be administered as a distinct department by the London School of Economics.

The following doctorates have been conferred:—*D.Sc.* (*Economics*): Mr. T. E. G. Gregory, an internal student, of the London School of Economics, for a thesis entitled "Tariffs: A Study in Method." *D.Sc.* (*Chemistry*): Mr. S. C. Bradford, an external student, for a thesis entitled "On the Theory of Gels," and other papers; and Mr. E. B. Maxted, an external student, for a thesis entitled "The Influence of Inhibitants on the Occlusion and Activation of Hydrogen by Palladium and Platinum," and other papers.

MANCHESTER.—The executors of the late Mr. Hermann Woolley, who was for many years treasurer of the University, have given a donation of 1000*l.* towards the endowment of a lectureship in pharmaceutics.

The following appointments have been made:—Reader in geography, Mr. W. H. Barker, of University College, Southampton; assistant lecturer in physics, Mr. W. S. Vernon; and assistant lecturer in chemistry (technology), Mrs. M. B. Craven.

OXFORD.—The Romanes lecture for 1922 will be delivered at 6 p.m. on May 24 in the Sheldonian Theatre by Prof. A. S. Eddington, Plumian professor of astronomy at Cambridge and president of the Royal Astronomical Society. The subject will be "The Theory of Relativity and its Influence on Scientific Thought."

On January 31 Congregation rejected by 65 votes to 62 the preamble of a statute by which it was proposed to discontinue the Delegacy of the University Museum, and to establish in its place a Board consisting of the heads of the departments of natural science in the University. The opinion of the teachers of science was divided on the question, some, both of the professors and of the college tutors, being opposed to the change. It is, however, probable that there is an almost general conviction that the present constitution of the Delegacy is capable of amendment, though the particular scheme of reform proposed by the Council did not commend itself to the majority. The statute was introduced by the Rev. G. B. Cronshaw, fellow of Queen's, and was supported by Sir C. S. Sherrington and Prof. W. H. Perkin and by the president of Magdalen. It was opposed by Mr. H. B. Hartley, fellow of Balliol, and by Mr. N. V. Sidgwick, fellow of Lincoln.

FIELD-MARSHAL LORD HAIG has been elected Chancellor of the University of St. Andrews in succession to the late Lord Balfour of Burleigh. Lord Haig was elected Rector of the University in 1917, and the office of Chancellor, to which he has now succeeded, is held for life.

ON Wednesday, February 8, at the Sir John Cass Technical Institute, Aldgate, E.C., Prof. W. Rothenstein, principal of the Royal College of Art, will distribute the prizes and certificates gained by the students during the past session and give an address on "Education and Industry."

Two Theresa Seessel research fellowships at Yale University are being offered, the object of which is the promotion of original research in biological studies. Applications for the fellowships, which are each of the value of 300*l.*, should be made to the Dean of the Graduate School, New Haven, Conn., U.S.A., before May 1 next, accompanied by reprints of scientific publications, letters of recommendation, and a statement as to the particular problem which the candidate expects to investigate.

IT is announced in the *British Medical Journal* that three Canadian universities—Toronto, Western, and Queen's—are co-operating with the Ontario Medical Association in a scheme similar to that adopted by the University of Bristol to keep medical practitioners in outlying districts in touch with recent developments in medicine by means of extension courses. The province has been divided into ten sections, and at a central point in each it has been arranged to hold various courses and give lectures covering a period of six weeks in each year. The courses have already commenced and have proved very popular, many practitioners travelling hundreds of miles to attend them.

Calendar of Industrial Pioneers.

February 2, 1876. Evan Leigh died.—The author of many improvements in cotton machinery and the writer of "The Science of Modern Cotton Spinning" (1871), Leigh was also known as one of the earliest advocates of twin-screw propellers for steamships.

February 2, 1906. Samuel Cunliffe Lister, first Baron Masham, died.—A worsted spinner and manufacturer, Lister took out more than 150 patents, among them being his wool-combing machines and his method of utilising silk waste. The wool-combing machine of the 'fifties cheapened cloth, advanced Bradford's prosperity, and created the Australian wool trade, while by his second great invention he converted what was regarded as useless into a valuable and beautiful material. He was raised to the peerage in 1891.

February 2, 1913. Carl Gustav Patrik de Laval died.—Born at Blosenberg, Sweden, in 1845, de Laval graduated at Upsala University, engaged in practical work, and in 1875 became engineer to the Klosterverken Iron Works. A year or two later he brought out his cream separator, an apparatus now in use throughout the world. Turning his attention to the invention of a steam turbine, he first applied the use of diverging nozzles, discs rotating at a great velocity, and high-speed tooth-gearing. In 1897 he exhibited a turbine supplied with steam at 1500 lb. pressure.

February 3, 1893. James Edward Henry Gordon died.—An original investigator, Gordon worked in Maxwell's laboratory at Cambridge, and in 1880 published "A Physical Treatise on Electricity and Magnetism." He afterwards became connected with some of the pioneer electrical installations in London.

February 4, 1882. Sir William Palliser died.—While an undergraduate at Cambridge Palliser began his study of rifled ordnance and projectiles, and afterwards, when in the Army, became known for his invention of a method of converting smooth bores into rifled guns and his introduction of chilled cast-iron shot.

February 4, 1884. George Auguste Leschot died.—An eminent Swiss horologist, Leschot was one of the first to introduce machinery for making the parts of watches and to make such parts interchangeable. He was also the first to propose the use of the black diamonds of Brazil for the boring of rocks, and with another Geneva mechanician made the first diamond-pointed drill.

February 6, 1877. George Parry died.—Though commencing life as a grocer's assistant, Parry studied the chemistry of iron manufacture, and in 1848 became chemist to the Ebbw Vale Works, where he worked at the utilisation of waste gases, tried Nasmyth's idea of puddling with steam, and made many early experiments in connection with the Bessemer process.

February 7, 1866. David Elder died.—One of the earliest builders of marine steam engines, Elder in 1821 became manager to Robert Napier at Camlachie. He introduced many improvements in his engines, and was one of the first to use steam expansively.

February 7, 1879. Bennet Woodcroft died.—The son of a Lancashire merchant and a pupil of Dalton, Woodcroft became a silk and muslin manufacturer and made valuable improvements in looms and patented various forms of screw propellers. From 1847 to 1851 he was professor of machinery in University College, London, and on the passing of the important Patents Act of 1852 became superintendent of patent specifications. In 1864 he became Clerk to the Commissioners of Patents. He was mainly responsible for starting the Patent Office Library and the Patent Office Museum. E. C. S.

Societies and Academies.

LONDON.

Royal Society, January 26.—Sir Charles Sherrington, president, in the chair.—W. A. **Bone**, A. R. **Pearson**, E. **Sinkinson**, and W. E. **Stockings**: Researches on the chemistry of coal. Pt. 2: The resinic constituents and coking propensities of coals. Prolonged extraction of eight selected coals by typical resin-solvents in a Soxhlet apparatus has no appreciable effect upon their coking propensities, which therefore cannot be ascribed to the presence of free resins. A resin isolated by a new method from two typical bituminous coals has a molecular weight of about 450, agreeing with the empirical formula $C_{31}H_{32}O_3$; its properties correspond with those of a resene in Tschirch's classification of resins. The usual pyridine–chloroform method of extracting coals does not effect a complete separation between the resinous constituents and the degradation products of the cellulose of which coal is conglomerated. It yields an admixture of resins with a predominance of non-resinous substances of cellulosic origin, provisionally designated "humic" bodies. These substances may amount to 4 per cent. of the coal substance. The strong coking propensities of some coals are principally due to the presence, or formation in them by heat, of such non-resinous "humic" substances of cellulosic origin the fusion temperatures of which are below those at which they undergo rapid decomposition; the more complex substances of cellulosic origin, which form the main portion of the coal substance and decompose without fusion, have little or no influence upon the coking properties.—J. A. **Crowther** and B. J. **Schonland**: The scattering of β-rays. The scattering of a homogeneous beam of β-rays has been measured for various elements, and at various angles with the beam. The results obtained are compared with the nuclear theory of scattering of Sir Ernest Rutherford, a correction being applied to allow for the variation of the mass of the β-particle with velocity. Scattering is due to single encounters between the β-particle and the deflecting particles as postulated by the theory until the thickness of the scattering material reduces the radiation to half value. The scattering by gold is in numerical agreement with the theory when measured at very small angles with the primary beam. It increases rapidly as the angle is increased, and finally attains a value approximately four times that given by the theory. This high value is given by the lighter elements at all the angles investigated. Present theories of scattering require modification when the collisions between the β-particle and the deflecting nucleus are closer than a certain critical distance which is of the order of 10^{-10} cm. in the case of gold.—Ann C. **Davies**: The minimum electron energies associated with the excitation of the spectra of helium. The lines of the orthohelium and parhelium series are simultaneously excited when ionisation of the helium atom has occurred. The limiting voltages for excitation are 20·4 and 25·2, according to whether ionisation by multiple impacts can occur or not. The corresponding voltages in the case of the enhanced line λ4686 are 54·2 and 80·0 respectively. This line can also be excited from the helium positive ion without further ionisation of the atom at 50·8 volts, the value deduced from Bohr's theory. The minimum voltage for the appearance of the helium band spectrum is 20·4, and the conditions indicate that it is emitted by He_2 molecules. Orthohelium and parhelium lines and the band spectrum are maintained as the voltage is backed down to 13 volts at high pressures.—C. N. **Hinshelwood**, H. **Hartley**, and

B. **Topley**: The influence of temperature on two alternative modes of decomposition of formic acid. Formic-acid vapour in contact with glass surfaces between 200° and 300° C. decomposes mainly in the following ways:—

$$(a)\ H\cdot COOH = CO_2 + H_2$$
$$(b)\ H\cdot COOH = CO + H_2O$$

The two modes of decomposition proceed at approximately equal rates, but the critical energies calculated from the temperature-coefficients of the respective velocity constants are so different that one reaction should predominate almost entirely unless a phase restriction is introduced. In this case molecules with the necessary critical internal energy do not react at once unless they are in a certain phase.—C. V. **Raman**: The molecular scattering of light in water and the colour of the sea.

Geological Society, January 4.—Dr. G. T. Prior, vice-president, in the chair.—W. D. **Lang**, L. F. **Spath**, and W. A. **Richardson**: Shales-with-beef, a sequence in the Lower Lias of the Dorset coast. Pt. 1: Stratigraphical, by W. D. Lang. The shales-with-beef lie between Table Ledge below and the Birchi Bed above, and consist of an upper 30 ft. of brownish paper-shales with selenite, "beef," and limestone-nodules and lenticles; and a lower 40 ft. of bluish conchoidal marls with indurated marl-beds, beef, and limestone-nodules and lenticles. The main palæontological divisions were given. Pt. 2: Notes on the ammonites, by L. F. Spath. The genera of ammonites found in the shales-with-beef are recorded, and remarks made on their classification and phylogeny. Pt. 3: Petrological Notes, by W. A. Richardson. During sedimentation, calcium carbonate gradually accumulated in solution in the water-logged deposit, and a system of limestones and calcareous nodules was precipitated rhythmically during the initial stages of desiccation. Later, veins of fibrous calcite were deposited at levels of low pressure. On the final drying of the deposit the remaining solutions of calcium carbonate were ultimately deposited as a cementing material.

Optical Society, January 12.—Mr. R. S. Whipple, president, in the chair.—C. J. **Peddle**: The manufacture of optical glass. The history of the manufacture of optical glass can be divided into four epochs, Guinand's discovery of the stirring process in 1796, the work of Abbe and Schott about 1882, and the development in England during the great war being the outstanding features in this history. The method of manufacture is practically the same at the present time as in Guinand's day, any improvement being one of degree rather than of kind. For successful production of the various types the effects of composition upon density, refractive index, melting properties, durability, freedom from colour, and devitrification tendencies have to be studied upon a small scale and the results translated into terms suitable for works practice.—J. W. **French**: The Barr and Stroud 100-ft. self-contained base range-finder. This range-finder has a new type of triple field. It is carried upon a mounting comprising two trucks running upon a roller path of 50 ft. diameter, the trucks being connected by a rigid horizontal framework. Upon the trucks are carried cantilevers, from the ends of which are suspended cradles having special bearings within which the range-finder rests. Training is done by power or by hand. During extensive tests the uncertainty of observation at a range of 31,000 metres did not exceed 20 metres.—T. **Smith**: The optical three-apertures problem. In such an instrument as a submarine periscope, where broad beams of light have to be transmitted down a long tube from a wide field, the relation between the length and diameter of the tube and the number of lenses is considered. Various types of construction are indicated, together with the relative advantages offered by them.

SHEFFIELD.

Society of Glass Technology, January 18.—Dr. M. W. Travers, president, in the chair.—W. L. **Baillie**: An examination and extension of Zulkowski's theory of the relation between the composition and durability of glass. Zulkowski's theory assumes that the essential reactions involved in the founding of glass are the formation of simple silicates of the alkalies and alkaline earths which combine to form double silicates. In these reactions the bases are regarded as competing equally for the acids, and it is assumed that all the materials of the batch enter completely into reaction. If one type of base be molecularly in excess, simple silicates remain in the glass, and are regarded as the prime cause of instability. The difference between Zulkowski's original theory and that now proposed is essentially in the different quantities deduced for the number of molecules of simple silicates present. The term "basic excess" is replaced by a more complete function, for which the term "reactivity coefficient" is suggested. Glasses of satisfactory resistance have reactivity coefficients of under three units. Negative values were generally associated with the most stable glasses, though very large negative values are probably undesirable.—W. E. S. **Turner**: A critical note on the methods of determining the durability of glass. The method of stating the loss in weight due to the attack of reagents is not a trustworthy check. It is better, where possible, to determine either the amount of alkali liberated or the total weight of matter extracted. With boiling reagents flasks gave different results from beakers, and results differed according to the weight or volume of the reagent they contained; pieces immersed gave results different from those obtained where one surface only was in contact with the reagent. Four modes of testing were discussed:—(*a*) The static method with flasks and beakers, (*b*) the use of slabs and discs immersed in the reagent, (*c*) the autoclave test, and (*d*) a rapid method by grinding glass to pass mesh 20–30. The autoclave test was regarded as uncertain. For speed and convenience test (*d*) was advocated.—Miss C. M. M. **Muirhead** and W. E. S. **Turner**: The effect of magnesia on the durability of glass. Lime and magnesia glasses were compared. Resistance to attack by water was determined from tests on glass crushed to mesh 20–30 and boiled for one hour. The amount of sodium oxide set free was greater in the case of the lime glasses than in the case of the magnesia glasses. The results of tests on boiling discs in hydrochloric acid for six hours showed that a glass containing small amounts of magnesia was more resistant than the corresponding lime glass, but the difference between the resistance of the glasses is small when they contain 8 or more per cent. of lime or magnesia. Magnesia glasses are less resistant than lime glasses to attack by both sodium carbonate and caustic soda after boiling for three hours.

PARIS.

Academy of Sciences, January 16.—M. Emile Bertin in the chair.—The president announced the death of M. Ciamician, foreign associate.—F. E. **Fournier**: The relations between the form of the hull of a ship, the relative displacements of its satellite wave, its aptitude for speed, its most economical speed, and the resistance of the water to its translation.—C. **Guichard**: The Ω_{00} networks.—P. **Montel**: An exten-

sion of a theorem of M. Landau.—M. **Auric**: The generalisation of complex integral numbers.—M. **d'Ocagne**: The reduction of the fourth dimension to a plane representation.—G. **Tzitzéica**: Networks of points.—P. **Salet**: The pressures of the atmospheres of the stars and the sun. The iron lines of the types *a*, *b*, *c*, *d* of Gale and Adams being unequally displaced towards the red by the effect of pressure, and this displacement being sensibly proportional to the pressure, it is possible, measuring only the difference of displacement of lines of different types, to determine the pressure of the medium in which the lines are produced. The spectra of Procyon, Arcturus, and the sun have been studied from this point of view, and it has been found that the pressures of the atmospheres of the two stars are very slightly higher (1 to 2 atmospheres) than that of the sun. The pressure of the reversing layer of the sun would appear to be only some tenths of an atmosphere.—E. **Brylinski**: An interpretation of Michelson's experiment.—H. **Chaumat**: The application of the ballistic galvanometer to the testing of iron.—G. **Claude**: The accidents observed in the synthesis of ammonia by hyperpressures and on the means of avoiding them.—M. **Taffin**: Annealing and the mechanical properties of glass. The phenomenon of annealing of glass would appear to be only a viscous deformation under the action of internal stresses.—P. **Woog**: The velocity of extension of thin layers of oil on the surface of a sheet of water. From experiments on mineral and fatty oils a connection is traced between the velocity of extension of the oil film on water and the acidity, carboxyl groups of the glycerides, double linkages, and viscosity.—A. **Kling** and Mme. A. **Lassieur**: An apparatus for the determination of the concentration of a solution in hydrogen ions. Application to the detection of mineral acids in vinegar. A compensation method dispensing with the usual standard cell and capillary electrometer and making use of a millivoltmeter.—E. **Grandmougin**: Diphenylsulphone. Considerable quantities of diphenylsulphone, formed as a by-product during the sulphonation of benzine, were accumulated during the war. The author gives an account of some derivatives made with a view to their possible utilisation in the dye industry.—P. **Lemay** and L. **Jaloustre**: Some oxydasic properties of thorium-X. Thorium-X acts as a powerful catalyst in the oxidation of adrenaline and of morphine; on the other hand, no oxidation of the alcohols of the fatty series could be proved.—M. **Muguet**: Lead in the uranium minerals of Madagascar. In the course of the extraction of radium from the Madagascar mineral betafite, lead has been isolated in quantities representing about 0·6 per cent. of the mineral treated. This lead probably arises from the atomic disintegration of uranium; its radioactivity has increased regularly for six months.—M. **Leriche**: Vestiges of the Lutetian in the Quaternary of the north of France.—C. **Jacob**: The structure of north Annam to the north of Thanh Hoa.—L. **Joleaud**: The age of the calcium phosphate deposits of southern Morocco, Algeria, and Tunis.—H. **Joly** and N. **Laux**: The fauna of the middle and upper layers of the Aalenian of the Grand Duchy of Luxemburg.—A. **Boutaric**: The diurnal radiation of the atmosphere at Mont Blanc.—C. **Dufour**: Values of the magnetic elements at the Val-Joyeux station at Villepreux (Seine-et-Oise) on January 1, 1922.—M. **Bridel**: The presence of a glucoside giving rise to an essential oil in the stems and roots of *Sedum telephium*. The glucoside extracted from this plant hydrolysed with emulsin gives glucose and an essential oil smelling of roses. Hydrolysed with dilute sulphuric acid the essential oil undergoes a change, and the smell resembles eucalyptol or terpineol.—A. **Goris** and H. **Deluard**: The influence of solar radiation on the culture of belladonna and the formation of alkaloids in the leaves. Insolation favours the production of alkaloids in the leaves of belladonna, and also the size of the leaves.—C. **Oberthür** and C. **Houlbert**: Some new views on the classification of the Melanargia (Lepidoptera: Satyridæ).—C. **Champy**: The determination of the sexual characters in Tritons. A criticism of some views expressed by Bouin and Ancel.—B. **Roussy**: Measurement of the cutaneous surface of the horse.—M. **Marage**: Acuteness of hearing and aptitude for military service. Deafness alone should not be a cause of rejection for army service, a person entirely deaf being still capable of rendering service to the army in a suitable position.—J. **Dragoui**: The influence of osmotic pressure on cell division.—S. **Metalnikow**: Sterile death in infected caterpillars. Under certain conditions the phagocytes are successful in removing all the foreign organisms (cholera, sarcina, staphylococcus), but the caterpillar dies, although sterile.—M. **Schein**: The possible duality of aphthous fever.—H. **Vallée** and H. **Carré**: Anti-aphthous immunity.

BRUSSELS.

Royal Academy of Sciences, January 7.—M. Aug. Lameere in the chair.—H. **Lonay**: Contribution to the study of the relations and structure of the different parts of the ovule and of its general nutrition before and after impregnation.—P. **Bruylants**: Contribution to the study of the reaction of the organo-magnesium compounds on nitriles.

WASHINGTON, D.C.

National Academy of Sciences, Proceedings, vol. 7, No. 1 (January, 1921).—A. **Van Maanen**: Internal motion in the spiral nebula Messier 33. It is shown that the motion is along the arms of the spiral and is not a rotation of the nebula as a whole. The magnitude of the motions would indicate that the nebula is not comparable in dimensions with the galactic system.—L. B. **Loeb**: The attachment of electrons to neutral molecules in air. The mechanism of negative-ion formation in air lies in the electron attaching itself to the molecule to form the negative ion on the average in one out of 250,000 molecular impacts. It is to the oxygen molecule that the electron is attached.—F. G. **Benedict**, M. F. **Hendry**, and M. L. **Baker**: The basal metabolism of girls twelve to seventeen years of age. The basal heat production per kilogram of body-weight per twenty-four hours decreases regularly with increasing age from 30 Calories at twelve years to nearly 22 Calories at seventeen years.—R. A. **Millikan** and I. G. **Barber**: The reflection and re-emission of electrons from metal surfaces and a method of measuring the ionising potential of such surfaces. Contrary to current belief, there appears to be no such phenomenon as the direct reflection of an electron from a copper surface.—E. H. **Morris**: Chronology of the San Juan area. The establishment of a chronological scale for the area of San Juan gives us a succession of cultural periods during the greater part of the prehistoric period for the south-west.—W. **Bowie**: Some geologic conclusions from geodetic data. Geodetic evidence indicates that land masses are in isostatic equilibrium and that the equilibrium exists in a comparatively small area. It is inferred that land masses have been in equilibrium in former geologic periods, and that mountain systems formed in previous sedimentary areas are due to expansion of the material under them.—D. P. **Smith**: Experiments on the electrical conduction of a hydrogen alloy. The temporary supple-

mentary conduction exhibited by metals during the cathodic occlusion of hydrogen is not of ordinary metallic character.—J. A. **Harris** and E. W. **Sinnott**: The vascular anatomy of normal and variant seedlings of *Phaseolus vulgaris*. A comparative and biometric study of the gross vascular anatomy of the seedlings.—L. L. **Woodruff**: The present status of the long-continued pedigree culture of *Paramecium aurelia* at Yale University. The culture has attained to about 8900 generations during thirteen and a half years of life. Conjugation is not necessary, but there is a periodic endomyxis.

No. 2 (February, 1921).—A. J. **Dempster**: Positive-ray analysis of magnesium. Isotopes of weights 24, 25, and 26 combined in the ratio 1 : 1 : 6 are found.—C. **Barus**: The energy content of the diapason.—W. A. **Setchell**, T. H. **Goodspeed**, and R. E. **Clausen**: A preliminary note on the results of crossing certain varieties of *Nicotiana Tabacum*. One general result has been a demonstration of the difference from a genetic point of view between any two of a number of so-called fundamental varieties of *N. Tabacum*.—J. **Kendall**: The correlation of compound formation, ionisation, and solubility in solutions: Outline of a modified ionisation theory. It is assumed that ionisation is preceded by combination between solvent and solute, and is indeed a consequence of such combination.—E. H. **Hall**: The Peltier effect. Application of the author's recently proposed theories of electrical conduction on metals to the discussion of the Peltier effect.—J. H. **McDonald**: The roots of Bessel's functions.

Official Publications Received.

Bulletin of the American Museum of Natural History. Vol. 44, Art. 20: The Birds of the American Museum of Natural History's Asiatic Zoological Expedition of 1916-1917. By Outram Bangs. Pp. 575-612. (New York City.)

National Research Council. Organisation and Members, 1921-1922. Pp. 55. (Washington, D.C.)

Conseil Permanent International pour l'Exploration de la Mer. Rapports et Procès-Verbaux des Réunions. Vol. 27. Procès-Verbaux (Juillet, 1921.) Pp. 91. (Copenhague: Andr. F. Høst et Fils.)

Report of the Canadian Arctic Expedition, 1913-18. Vol. 3: Insects. Part K: Insect Life on the Western Arctic Coast of America. By F. Johansen. Pp. 62. (Ottawa.)

Canada. Department of Mines: Mines Branch. The Production of Coal and Coke in Canada during the Calendar Year 1920. Pp. iv +36. (Ottawa.)

The Institution of Civil Engineers. Engineering Abstracts from Current Periodical Literature. Supplement to the Minutes of Proceedings of the Institution. New Series, No. 10, January. Pp. 228. (London: The Institution of Civil Engineers.)

Anales del Museo Nacional de Historia Natural de Buenos Aires. Tome 30. Pp. viii+559+22 plates+maps. (Buenos Aires.)

República Argentina. Ministerio de Agricultura de la Nación: Oficina Meteorologica Naciónal. Boletin Mensual Año 4, Numero 1. Enero de 1919. Pp. 51+maps. (Buenos Aires.)

Agricultural Research Institute, Pusa. Bulletin No. 120: The Serum Simultaneous Method of Inoculation against Rinderpest. By W. A. Pool. Pp. ii+7. 2 annas. Bulletin No. 121: Notes on Contagious Abortion in Pony and Donkey Mares. By R. Branford and T. M. Doyle. Pp. ii+12. 5 annas (Calcutta: Government Printing Office.)

Scientific Reports of the Agricultural Research Institute, Pusa (including the Reports of the Imperial Dairy Expert and the Secretary, Sugar Bureau), 1920-21. Pp. iv+90+10 plates. (Calcutta: Government Printing Office.) Rupees 1.8.

Communications from the Physical Laboratory of the University of Leiden. Supplement No. 44 to Nos. 157-168. Pp. 74. (Leiden.)

Department of Agriculture, Ceylon. Bulletin No. 48: Summary of Laws and Regulations in Force in Ceylon in Respect of Plant Pests and Diseases. Pp. 6. 50 cents. Bulletin No. 49: The Cultivation of Limes. By G. G. Auchinleek. Pp. 18+2 plates. 50 cents. Bulletin No. 50. The Cultivation of Pineapples in Ceylon. By F. A. Stockdale. Pp. 12+4 plates. 50 cents. (Peradeniya: Department of Agriculture.)

Ceylon Administration Reports for 1920. IV.: Education, Science, and Art. Department of Agriculture: Report of the Director of Agriculture for 1920. Pp. 38. (Peradeniya: Department of Agriculture.)

Memoirs of the Department of Agriculture in India. Chemical Series, Vol. 6, No. 2, September. 1*s.* 3*d.* Nos. 4 and 5, October. 2*s.* 9*d.* (Calcutta: Thacker, Spink and Co.; London: W. Thacker and Co.)

Diary of Societies.

THURSDAY, FEBRUARY 2.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir Napier Shaw: Droughts and Floods (1).

ROYAL SOCIETY, at 4.30.—C. Shearer: The Oxidation Processes of the Echinoderm Egg during Fertilisation.—J. Schmidt: The Breeding Places of the Eel.— J. Gray: The Mechanism of Ciliary Movement.—J. Gray: The Mechanism of Ciliary Movement. Parts 1 and 2.—J. S Huxley and L. T. Hogben: Experiments on Amphibian Metamorphosis and Pigment Responses in Relation to Internal Secretions.

LINNEAN SOCIETY OF LONDON, at 5.—F. Johanssen: The Canadian Arctic Expedition.—Dr. J. C. Willis and U. Yule: Some Statistics of Evolution and Distribution in Plants and Animals, and their Significance.—Mrs. E. M. Reid: Note on Fossil Floras.

ROYAL SOCIETY OF MEDICINE (Medicine Section), at 5.—Sir William Hale-White, Sir William Willcox, Sir Berkeley Moynihan, and Mr. Sherren: Discussion: The Treatment of Gastric Ulcer.

INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—L. J Romero and J. B. Palmer: The Interconnection of A.C. Power Stations.

CHEMICAL SOCIETY, at 8.—E. J. Hartung: The Action of Light on Silver Bromide.—C. K. Ingold: The Structure of the Benzine Nucleus. Part I. Intra-nuclear Tautomerism.—C. K. Ingold: The Structure of the Benzine Nucleus. Part II. Synthetic Formation of the Bridged Modification of the Nucleus.—C. K. Ingold and H. A. Piggott: The Structure of the Benzine Nucleus. Part III. The Suppression of Intra-nuclear Change.

FRIDAY, FEBRUARY 3.

INSTITUTE OF COST AND WORKS ACCOUNTANTS (at Holborn Restaurant), at 2.30.—Costing Conference on the Necessity for Scientific Costing.

ROYAL SOCIETY OF MEDICINE (Laryngology Section), at 4.45.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. K. M. Walker: The Nature and Cause of Old Age Enlargement of the Prostate (Hunterian Lecture).

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—H. S. Denny and N. V. S. Knibbs: Some Observations on a Producer-gas Power Plant.

EUGENICS EDUCATION SOCIETY (at Royal Society), at 8.—Prof. H. J. Fleure: Some Social Bearings of Race Study.

JUNIOR INSTITUTION OF ENGINEERS, at 8.—Major W. Gregson: Utilisation of Waste Heat from Internal Combustion Engines.

ROYAL SOCIETY OF MEDICINE (Anæsthetics Section), at 8.30.—Dr. A. L. Flemming and others: Discussion: The Uses and Limitations of N_2O and O_2 Anæsthesia.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Sir Francis Younghusband: The Mount Everest Expedition.

MONDAY, FEBRUARY 6.

VICTORIA INSTITUTE (at 1 Central Buildings, Westminster, S.W.1), at 4.30.—Dr. A. T. Schofield: Some Difficulties of Evolution.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. A. H. Todd: Orthopædic Aspects of Rheumatoid Arthritis (Hunterian Lecture).

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.—General Meeting.

SOCIETY OF ENGINEERS, INC. (at Geological Society), at 5.30.—T. J. Gueritte: Presidential Address.

INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting), at 7.—J. Joseph and others: Discussion: Some Practical Applications of the Thermionic Valve.

ARISTOTELIAN SOCIETY (at University of London Club, 21 Gower Street, W.C.1), at 8.—A. H. Hannay: Standards and Principles in Art.

ROYAL SOCIETY OF ARTS, at 8.—C. Ainsworth Mitchell: Inks (Cantor Lectures) (3).

SOCIETY OF CHEMICAL INDUSTRY (London Section) (at Chemical Society), at 8.

SURVEYORS' INSTITUTION, at 8.—Adjourned Discussion on paper by W. R. Davidge: The Problems of Greater London.

ROYAL INSTITUTE OF BRITISH ARCHITECTS, at 8.30.—President's Address to Students.

ROYAL GEOGRAPHICAL SOCIETY (at Æolian Hall), at 8.30.—Brig.-Gen. G. K. Cockerill: Byways in Hunza and Chitral.

TUESDAY, FEBRUARY 7.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. H. H. Turner: Variable Stars (2), Long Period Variables.

ROYAL SOCIETY OF ARTS (Dominions and Colonies Section), at 4.30.—W. Turnbull: The Timbers of British Columbia.

ZOOLOGICAL SOCIETY OF LONDON, at 5.30.—The Secretary: Report on the Additions made to the Society's Menagerie during the months of November and December, 1921.—A. H. Evans: Some Deductions from a Set of Cuckoo's Eggs taken near Cambridge, and now Exhibited.—Lord Clifford of Chudleigh: *Nototherium mitchelli*.—Miss L. E. Cheesman: (1) Sense-organs of the Freshwater Crab, *Cardisoma armatum*. (2) Position and Function of the Siphon in the Amphibious Mollusc, *Ampullaria vermiformis*.—C. W. Hobley: The Fauna of East Africa and its Future.—Dr. J. Stephenson: Contribution to the Morphology, Classification, and Zoogeography of Indian Oligochæta.—IV. The Diffuse Production of Sexual Cells in a Species of *Chaetogaster* (Fam. Naididæ). V. *Drawida japonica* (Michlsn.), a Contribution to the Anatomy of the Moniligastridæ. VI. The Relationships of the Genera of Moniligastridæ; with Some Considerations on the Origin of Terrestrial Oligochæta.

INSTITUTION OF CIVIL ENGINEERS, at 6.—Dr. H. F. Parshall: Hydro-electric Installations of the Barcelona Traction, Light, and Power Company.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—O. J. Wilkinson: The Application of Flashlight Photography to the Study of Natural History Subjects.

RÖNTGEN SOCIETY (at Institution of Electrical Engineers), at 8.15.—W. H. Wilson: A New High-tension Generator for X-ray and other work.—H. C. Head: Canny Ryall Diathermy Apparatus; Ionostat; A New Iontoquantimeter; New X-ray Protective Material.—H. E. Donithorne: The Taylor Jones Electrostatic Oscillograph; A New Design of Gold Leaf Electroscope.—C. Andrews: A New Boiling-water X-ray Tube.—F. R. Butt and Co., Ltd.: Diathermy Apparatus.—E. E. Burnside: A New Model of X-ray Table.

WEDNESDAY, FEBRUARY 8.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. A. G. T. Fisher: A Research into the Pathology and Ætiology of Osteo-arthritis, with Observations upon the Principles underlying its Treatment (Hunterian Lecture).

INSTITUTION OF AUTOMOBILE ENGINEERS (at Institution of Mechanical Engineers), at 8.—E. L. Bass: Engine Lubrication.

ROYAL SOCIETY OF ARTS, at 8.—E. V. Evans: Some Solved and Unsolved Problems in Gas Works Chemistry.

MEDICAL SOCIETY OF LONDON (at 11 Chandos Street, W.1), at 9.—Sir Leonard Rogers: Amœbic Liver Abscess: Its Pathology, Prevention, and Cure (Lettsomian Lectures) (2).

THURSDAY, FEBRUARY 9.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir Napier Shaw: Droughts and Floods (2).

ROYAL SOCIETY, at 4.30.—*Probable Papers.*—Sir J. A. Ewing: The Atomic Process in Ferro-magnetic Induction.—Prof. J. W. Nicholson: Problems relating to a Thin Plane Annulus.—Prof. T. H. Havelock: The Effect of Shallow Water on Wave Resistance.—R. H. Fowler and S. N. H. Lock: The Aerodynamics of a Spinning Shell. Part II.—F. P. Pidduck: The Kinetic Theory of a Special Type of Rigid Molecule.—J. E. Jones: The Velocity Distribution Function and the Stresses in a Non-uniform Rarefied Monatomic Gas.—H. Bateman: The Numerical Solution of Linear Integral Equations.

LONDON MATHEMATICAL SOCIETY (at Royal Astronomical Society), at 5.—H. Hilton: Conics on the Pseudo-sphere.—W. F. D. MacMahon: The Theory of Closed Repeating Polygons in Euclidean Space of Two Dimensions.—G. H. Hardy and J. E. Littlewood: Dirichlet's Series with a Barrier of Singularities.

INSTITUTION OF CIVIL ENGINEERS (Students' Meeting), at 6.—E. J. Kingston-McCloughry: The Design of Modern Water-turbines.

OPTICAL SOCIETY (at Imperial College of Science and Technology), at 7.30.—Annual General Meeting.—F. W. Preston: The Structure of Abraded Glass Surfaces.—A. J. Dalladay and F. Twyman: The Stress Conditions Surrounding a Diamond Cut in Glass.—Lt.-Col. J. W. Gifford: A Supplementary Note on Achromatic One-Radius Doublet Eyepieces.—F. Twyman and A. J. Dalladay: Change in Refractive Index at the Surfaces of Glass Melts.

CHEMICAL SOCIETY (at Institution of Mechanical Engineers), at 8.—Sir Ernest Rutherford: Artificial Disintegration of Elements.

INSTITUTE OF METALS (London Section) (at Sir John Cass Technical Institute, Jewry Street, E.C.3), at 8.—R. T. Rolfe: Gun-metal.

FRIDAY, FEBRUARY 10.

PHYSICAL SOCIETY OF LONDON (at Imperial College of Science and Technology), at 5.—Annual General Meeting.—Dr. E. A. Owen and Bertha Naylor: The Measurement of the Radium Content of Sealed Metal Tubes.—Sir William Bragg: The Crystal Structure of Ice.—Dr. K. Grant: A Method of Exciting Vibrations in Plates, Membranes, etc., Based on Bernouilli's Principle.

ROYAL ASTRONOMICAL SOCIETY, at 5.—Anniversary Meeting.

ROYAL COLLEGE OF SURGEONS OF ENGLAND, at 5.—Prof. A. C. Pannett: Hydronephrosis (Hunterian Lecture).

KING'S COLLEGE ENGINEERING SOCIETY (Anniversary Meeting) (at Institution of Civil Engineers), at 5.30.—F. W. Macaulay: Water Engineering.

JUNIOR INSTITUTION OF ENGINEERS, at 8.—Questions and General Discussion.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Prof. W. D. Halliburton: The Teeth of the Nation.

PUBLIC LECTURES.

(*A number in brackets indicates the number of a lecture in a series.*)

THURSDAY, FEBRUARY 2.

INFANTS' HOSPITAL (Vincent Square, S.W.1), at 4.—Dr. W. M. Feldman: The Physiology and Pathology of Ante-natal and Early Post-natal Life (1).

KING'S COLLEGE, at 5.30.—Dr. O. Faber: Reinforced Concrete (3).

ST. JOHN'S HOSPITAL FOR DISEASES OF THE SKIN (Leicester Square, W.C.2), at 6.—Dr. J. L. Bunch: Drug Eruptions (Chesterfield Lecture).

CIVIC EDUCATION LEAGUE (at Leplay House, 65 Belgrave Road, S.W.1), at 8.15.—Miss Barbara Low: Psycho-analysis in relation to Civics.

FRIDAY, FEBRUARY 3

METEOROLOGICAL OFFICE (South Kensington), at 3.—Sir Napier Shaw: The Structure of the Atmosphere and the Meteorology of the Globe (3).

UNIVERSITY COLLEGE, at 5.—Prof. G. Elliot Smith: The Evolution of Man (1); at 6.—Miss E. Jeffries Davis: London and its Records.

KING'S COLLEGE, at 5.30.—Rev. Dr. F. A. P. Aveling: Matter, Mind, and Man.—Dr. H. W. Williams: The Peoples of the Caucasus (3).

TAVISTOCK CLINIC FOR FUNCTIONAL NERVE CASES (at the Mary Ward Settlement, Tavistock Place, W.C.1), at 5.30.—Dr. H. Crichton Miller: The New Psychology and its Bearing on Education (2).

SATURDAY, FEBRUARY 4.

SALTERS' HALL (St. Swithin's Lane, E.C.4), at 10.30 a.m.—Dr. M. O. Forster: The Relation between Pure and Applied Chemistry.

LONDON DAY TRAINING COLLEGE, at 11 a.m.—Prof. J. Adams: The School Class (3).

HORNIMAN MUSEUM (Forest Hill), at 3.30.—E. Lovett: The Folk-lore of Natural History.

MONDAY, FEBRUARY 6.

UNIVERSITY COLLEGE, at 5.15.—Sir Gregory Foster: The University of London: Its History, Present Resources, and Future Possibilities (1).

CITY OF LONDON (BOYS') SCHOOL, at 5.30.—Miss Rosa Bassett: The Dalton Plan of Self-education (1).

KING'S COLLEGE, at 5.30.—Prof. C. L. Fortescue: Wireless Transmitting Valves (3).—Dr. J. Steppat: Recent Developments in German Education and Student Life (3).

TUESDAY, FEBRUARY 7.

KING'S COLLEGE, at 5.30.—F. H. Rolt: Accurate Measurements in Mechanical Engineering: The Use and Testing of Gauges (2).

WEDNESDAY, FEBRUARY 8.

SCHOOL OF ORIENTAL STUDIES, at 5.—W. Doderet: Racial Types in the Bombay Presidency.

HORNIMAN MUSEUM (Forest Hill), at 6.—W. W. Skeat: The Living Past in Britain (3).

THURSDAY, FEBRUARY 9.

UNIVERSITY COLLEGE, at 5.15.—Prof. J. E. G. de Montmorency: Welsh and Irish Tribal Customs (1).

KING'S COLLEGE, at 5.30.—Dr. O. Faber: Reinforced Concrete (4).—M. Beza: Nereids in Roumanian Folk-lore.

TAVISTOCK CLINIC FOR FUNCTIONAL NERVE CASES (at the Mary Ward Settlement, Tavistock Place, W.C.1), at 5.30.—Dr. H. Crichton Miller: The New Psychology and its Bearing on Education (3).

ST. JOHN'S HOSPITAL FOR DISEASES OF THE SKIN (Leicester Square, W.C.2), at 6.—Dr. W. Griffith: The Skin Eruptions of Syphilis (Chesterfield Lecture).

FRIDAY, FEBRUARY 10.

METEOROLOGICAL OFFICE (South Kensington), at 3.—Sir Napier Shaw: The Structure of the Atmosphere and the Meteorology of the Globe (4).

SATURDAY, FEBRUARY 11.

LONDON DAY TRAINING COLLEGE, at 11 a.m.—Prof. J. Adams: The School Class (4).

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Miss M. A. Murray: The Domestic Life of the Ancient Egyptians.

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