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Large Scale Research in Abstract Science.

SEVERAL recent lectures and addresses have given prominence to the interconnexion between abstract science and industry and the marked influence of science on industrial progress. Among these may be mentioned two addresses by Sir J. J. Thomson, the first at the opening of the new laboratories of the General Electric Company at Wembley and the second from the chair as president of the Institute of Physics, the James Forest lecture of the Institution of Civil Engineers, and, most recent of all, the fourteenth Kelvin lecture of the Institution of Electrical Engineers by Prof. J. A. Fleming.

Prof. Fleming deals with problems in telephony, solved and unsolved, and illustrates in a remarkable way and with great knowledge and insight the consequences of scientific inquiry in the past, and the need for further researches in the future. Graham Bell died last year; Kelvin in 1876 had returned from the American Centennial Exhibition at Philadelphia to take the chair of Section A of the British Association at Glasgow, full of the invention of the telephone, which he described in his own inimitable manner, and Prof. Fleming, who forty-six years ago had been one of his audience at Glasgow, writes :

"In the year, therefore, following that of the decease of the illustrious inventor of the speaking telephone it is perhaps appropriate that the Kelvin Lecture should direct attention to some of the problems of telephony which have been solved or which remain unsolved."

The solved problems are sufficiently wonderful; the amplitude of the air vibrations in a just audible sound varies from about 10^{-8} cm. at a frequency of (say) 256 to rather more than 10^{-11} cm. at the highest audible frequencies, and minute motions such as these are impressed on the telephone diaphragm, translated into the variations of an electric current, transmitted to a distance, there amplified, communicated to the receiver, and from it to the observer's ear. Fleming's Kelvin lecture is a fascinating story of the many steps by which this has been achieved, showing how by degrees workers in various lands have each contributed their quota to the advance and made speech possible over 2000 or perhaps 3000 miles by aerial lines, 500 miles by underground, and 200 miles by submarine cables.

This progress rests on the theoretical investigation by Heaviside of the conditions for undistorted transmission, the application of this work, with successive improvements, by Pupin and Krarup and others to the loading of cables and the advances available by the use of the thermionic valve as an amplifier and as the originator of "carrier" waves, rendering possible multiple telephony.

For the application of the valve as a rectifier of electric currents, we have to thank Fleming himself, while its whole action depends on the properties of the electron and the discoveries of J. J. Thomson. By the use of the valve as a repeater, many ingenious relays, the outcome of long and difficult investigations, have been placed in a secondary position; the lecturer explains in some detail how, by the selection of the suitable part of its characteristic curve, variations in the grid voltage can be impressed on the plate current and amplified by a transformer, while if another portion of the characteristic be employed, carrier wave multiple telephony is realised. In this "frequency filters" are employed—short circuits containing capacity and inductance which allow only those currents in which the frequency lies between certain limits to enter the line. The broad principles of the method are outlined thus:

"At one end of an existing long-distance telephone line used in the ordinary way for telephonic speech we can attach a certain number of modulating valves with their plate circuits coupled to the line with their appropriate transformers and filters. We can then generate by means of a number of oscillating valves high frequency currents of certain different frequencies and apply the electromotive forces due to these in series with the electromotive forces of low or speech frequency produced by ordinary carbon microphone transmitters so as to give to the grids of the several modulating valves carrier frequency plus voice frequency voltages. At the receiving end we separate out the several groups of oscillations by suitable band filters and apply the electromotive forces produced by suitable transformers to the grids of demodulating valves. In the plate circuits of these last valves we have coupled ordinary telephone receivers actuated by the voice currents disentangled by these demodulating valves from their respective carrier circuits."

Such has been the progress of less than fifty years. Fleming asks somewhat despondingly what is being done now in Great Britain. He refers to the laboratories of the great technical corporations of the United States, the American Telephone and Telegraph Company, the Western Electric Company, and the General Electric Company, giving an account of their activities in almost the same terms as those employed by Sir J. J. Thomson in his address to the Institute of Physics. "They retain," he writes, "the services of scientific investigators of the highest ability, who direct their attention not exclusively to problems of immediate commercial advantage, but look far ahead into the possible requirements of the future." Sir J. J. Thomson described two of these laboratories as seen by him during his recent visit to the United States. He found men at work on the most abstruse questions of physics—one need only mention Langmuir and the properties of the atom, or Coolidge and the investigations which led to the development of the Coolidge tube. There were numerous staffs of skilled assistants, some no doubt engaged in solving conundrums put to them by puzzled works managers, but many others searching deep into the secrets of Nature in the endeavour to find out new truths and to advance natural knowledge. Funds were practically unstinted, for the business directors of the works had found that by this means only could they extend the sphere of their activities and provide the dividends called for by their shareholders. In the United States abstract science has been made to pay.

Or to turn to another subject and another speaker. Quite recently the Wilbur Wright lecture, established by the Royal Aeronautical Society in memory of the American pioneer of aviation, was delivered in London by Prof. Ames, of the Johns Hopkins University. Prof. Ames is the chairman of the Executive Committee of the National Advisory Committee for Aeronautics of the United States, and directs the experimental work—full scale and model—of that committee at Langley Field. He has realised very fully the importance of an accurate knowledge of the air pressures on any part of aircraft undergoing manœuvres in the air; we were well aware of this, and years ago had done model experiments at the National Physical Laboratory, while at Farnborough apparatus for use in the air had been devised and some few experiments made. Prof. Ames showed slides illustrating in a most striking way the results obtained both on aeroplanes and airships, leading to information in the case of the latter which the Aeronautical Research Committee has pressed for many times, and which, had it been available in time, should have prevented the accident to the British airship R38.

Nor is this all: instruments have been successfully constructed which permit all the elements which contribute to a knowledge of the flight of an aeroplane—its velocities, accelerations, and the stresses to which its various parts are subject in the air—to be recorded during its flight. Instruments corresponding to some of these, such as the quartz-fibre accelerometer or the control force measuring stick, have been in existence at the Royal Aircraft Establishment for years; instruments corresponding to all have been planned and are in various stages of construction. In the United States they have found a man gifted with the knowledge to realise their need and with the authority to give effect to his knowledge. In England we have lagged behind.

So it is in other subjects; Great Britain is a small country, it is true, compared with the United States.

We owe much—in more senses than one—to our transatlantic kinsfolk, and we are piling up a debt which will prove more serious than the millions of the funding loan. What are we doing, what can we do, to reduce the load, to equalise the position?

The General Electric Company has its new laboratories at Wembley finely equipped and guided in the proper spirit. "The question," Mr. Paterson writes, "is sometimes asked whether the laboratories undertake pure research or confine themselves to applied research," and his answer is that "the question is meaningless." "A research laboratory," he holds, "is not complete unless it contains members interested in almost every branch of science and provides facilities for these and also for other classes of work."

The National Physical Laboratory devotes much of the energy of its staff to abstract science, though telegraphy and telephony have not figured largely in its programme; these are catered for to some extent by the Post Office Research Laboratory at Dollis Hill. For metallurgical work we have the Brown Firth research laboratories and the Hadfield Laboratory at Sheffield; other firms have laboratories in which occasionally an investigation in pure science is carried out. But as a rule a work's laboratory is mainly occupied in controlling the normal product of the works, testing the materials supplied, and assisting the works managers in maintaining a proper standard.

Then there are the laboratories of the Research Associations established and in part financed by the Department of Scientific and Industrial Research; good and valuable work is being done by these, but the co-operative system has its obvious disadvantages, and in but few is abstract science pressed very far.

Our best hope for the future would seem to be with the universities, but here again the want of funds is an almost fatal handicap. "There is not," writes Prof. Fleming, "as far as I am aware a single university in this country which possesses the necessary equipment for conducting advanced experimental research in telephony and telegraphy"; and this is true of many other subjects.

Research is terribly expensive. We have always had men of the highest scientific originality who in the past have been pioneers in the advance of knowledge; we have them still, but somehow we fail to estimate their value; we are reluctant to furnish them with the means alone by which their natural gifts may be utilised. The application of science can be organised, and many steps have been taken in recent years to improve its organisation, but if we wish to utilise scientific progress to prevent waste and to increase the efficiency of industry we must support the solitary genius working often for a mere pittance in some university or college laboratory and devoting all his powers to unravelling a little further the tangled skein of Nature's mysteries. Success in the struggle depends on finding the right man and in affording him full facilities. We have the men; will our legislators who control the nation's purse see that facilities are not wanting for their work?

R. T. GLAZEBROOK.

An Epitome of Antarctic Adventure.

The Life of Sir Ernest Shackleton, C.V.O., O.B.E. (Mil.), LL.D. By Hugh Robert Mill. Pp. xv+312+20 plates. (London: William Heinemann, Ltd., 1923.) 21*s*. net.

BY common consent, Dr. Hugh Robert Mill, the author of "The Siege of the South Pole" and the friend and adviser of a generation of polar explorers, must be acclaimed the right man to tell us the story of the most brilliant career in modern Antarctic exploration. Not only has he long been the ablest chronicler and the most sympathetic critic of adventure and achievement in the southern seas, but he was also for long the friend and oftentimes the confidant of the subject of this biography. It was, therefore, with the keenest anticipation that we took up the book, anxious to see how a master hand would deal with a life so full of light and shade and a character compounded of such contrary impulses. The result is somewhat of a revelation, and whatever may be said in criticism of the book it must be acknowledged that the biographer has carried out his task worthily and has revealed to us the man as he was, fully and fairly. It was obviously no light task to reconcile the leader of magnificent sledge journeys with the unsuccessful dabbler in city finance, the platform lecturer, unconventional even to bluntness, with the sensitive lover of poetry, but it has been done with skill and understanding and the result will be to many a new Shackleton, undreamt of by those who knew but one of his many aspects.

The book is divided into three sections corresponding with somewhat indefinite periods in the life. In the first, styled "Equipment," we are introduced to a healthily mischievous boy with a taste for poetry and the sea, developing along normal lines into an efficient but scarcely an enthusiastic officer of the mercantile marine. So far the story is an ordinary one, and even to Dr. Mill's discerning eyes it foreshadows but little of the future. But then appears the nucleus round which his energy and ambition gathered. To the average reader the story becomes alive immediately his future wife appears on the scene and stirs him to an incentive which in his own words at the time is expressed by the wish "to make a name for myself and for her," though as yet the sphere of fame had not been selected.

The chance came with his appointment to the *Discovery* expedition, and he seized it with both hands. Though but a junior officer he was selected for the most important journey, and under the hardest conditions he learnt the manifold tricks of the sledger's trade. How well he learnt them was to be seen some six years later when he took his own expedition south equipped with improvements on the *Discovery* arrangements in every direction. Compared to his own ventures, that of the National Antarctic Expedition was perhaps a little rigid in character, a little complex both in resources and aims, and a little embarrassed by committee control from home. We find Shackleton going to the opposite extreme in these matters, and generally with success, but we believe he had much to thank his first polar school for, if it can be called a school when all were learning and no one taught. The apprenticeship to Antarctic service is followed by shore jobs and a life varied in the extreme, a period through which the biographer takes us most successfully and indeed humorously, concluding the first part of the book with what must have been most excellent training, Shackleton's unsuccessful candidature for the general election of 1906.

Then comes "Achievement," the thrilling story of the multiple successes of his *Nimrod* expedition, a story hitherto told only in Shackleton's own words and therefore affording scope for the biographer to add many new and personal notes which explain actions formerly incomprehensible. Such, for example, was his repeated endeavour to seek a base on King Edward Land, not because his judgment selected it but because of a compact with Scott. How heavily this promise weighed upon him is seen in one of the gems of the book, a quotation from his letter written at the time of the decision—forced upon him by circumstances—to go back upon a promise which bound him too hardly. The journeys that follow, the triumphs of organisation and endurance which make up the history of that expedition, are well and fairly told. Records were broken in all directions, and from the popular point of view it was indeed the achievement of the whole career. From the point of view of the student of character and of the discerning reader of polar literature it was not the climax, which was to come eight years later. Served by his great ability, mental as well as physical, and aided by what he himself liked to call his luck, but which was largely his own foresight, he went magnificently far. Yet, in a sense, he went no farther than many another great leader has gone, with a similar fortitude, that is to say, to the limit of safety. To our mind the true ability of his leadership was not shown until he had gone farther than safety permitted and yet brought back his men in safety. None will dare belittle the triumph, but we believe that posterity will regard the management of the retreat of the *Endurance* party as his masterpiece and not the attainment of the heart of the Antarctic.

In the chapters which follow, headed "Popularity" and "Unrest," the biographer records faithfully the honours by kings and emperors, the triumphal progress of lecture tours, and the ups and downs of precarious finance. These things had to be recorded since they were part of Shackleton's life, but one is impatient all the time to get away from an atmosphere which never really suited him however brilliantly he shone in it on occasion.

Then comes the third part of the book, "Bafflement," a title true enough in a popular sense, for the rebuffs of fate were now well-nigh continuous, but scarcely comprehensive enough to indicate the real essence of this period of his life, the paradox of lasting fame arising from apparent failure. The story of the *Endurance*, already well, if tersely, told by Shackleton himself, gains colour in the hands of this master of narrative, and so too does our picture of the man, always at his best when with his back to the wall. Of polar travel it may be said more truly than of most ventures that any fool can get into a tight place but that it takes a man to get out of it again. Paraphrasing, we may say that most polar leaders have dared to the utmost as Shackleton did, many have achieved the utmost limit of endurance as he did, but few indeed have retreated in good order from an almost hopeless position. One has only to read the long list of ghastly retreats in polar history to imagine what might have happened, and then to admire the hand that grew firmer and the spirit that grew more courageous as the outlook grew darker. The chapter concluding the account of the *Endurance* expedition would have been an artistic ending to the book had it been possible. Not that great service was not yet to come, but the story now becomes diffuse with the welter of war, and the man is but one of many instead of at the head of a few. The story of the *Quest* inconclusive so far as the man is concerned, and is brief. It shows Shackleton with the same extraordinary capacity for organisation and the same magnetic personality ensuring support from unexpected quarters and rallying most diverse elements round him. At the same time it shows his judgment somewhat dimmed or perhaps merely harried by considerations of finance and season, which hurried him off before his ship was really seaworthy.

The epilogue which closes the book is in Dr. Mill's very best style, and in many ways it gives us a clearer picture of the man than the recital of his deeds has done.

The book is a very notable addition to the library of Antarctic literature which the author has already enriched, and is singularly free from errors. We cannot miss the rare luxury of correcting Dr. Mill on points of fact, as for example on p. 68, where for "sea-ice" we should read "barrier-ice," or on p. 139, where for "2000 feet" given as the height of the gap between Mt. Hope and the mainland we should read "900 feet." Another slip of the pen is on p. 243, where the return journey of Mackintosh's party over the Barrier is described as "more trying even than that of Captain Scott." Otherwise all comparisons are wisely avoided, nor is an attempt made to assess the value of the life's work, which great as it was cannot be viewed as yet in its true perspective. More might have been said as to the character of the innovations made by Shackleton into polar work, from the point of view both of organisation and of methods of travel, though this was probably omitted as being too technical a subject for the book. If the first object of a biography is to enlist the sympathy of the reader for the man then the book is a signal success, for no one can read without emotion the vivid pictures of his doings and writings in so skilful a setting, and if excuse were needed for this biography at all it would lie in the fact that in the rapidly changing circumstances of polar organisation we may never again see such a man leading single-handed ventures to great success or triumphant failure.

F. DEBENHAM.

The Physics of the X-Rays.

Les Rayons X. Par Maurice de Broglie. (Recueil des Conférences-Rapports de Documentation sur la Physique. Vol. 1. 1re Série, Conférences 1, 2, 3. Édité par la Société *Journal de Physique.*) Pp. 164+5 planches. (Paris: Les Presses Universitaires de France, 1922.) 15 francs.

THE present volume is the first of a series of reports on physics edited by the French Physical Society and issued under the direction of an influential committee representing nearly a dozen institutions and societies in France. Each report is discussed at a number of conferences which are open to the public, and the report in its final form is published for the benefit of men of science, technicians, students, and others, who wish to make themselves *au courant* with the recent developments of the particular branch of knowledge in question. That such a scheme should be set afoot is not the least of a number of indications of a great scientific revival which our neighbours across the Channel are for their part endeavouring to stimulate.

A similar scheme has been initiated in the United States under the direction of the National Research Council, and already a number of volumes have been published. If we except the admirable reports published by the Physical Society of London, we cannot recall any similar organised endeavour in Great Britain to sum up the present state of knowledge in the various departments of science. Nevertheless, much has already been done by individual effort—as is perhaps the British way—and a number of British workers have already published valuable monographs on the various sections of physics with which their names are associated.

If the book before us is an earnest of the standard of attainment in the volumes still to come, there will be a warm welcome for the new series, which, we are informed, will deal with such subjects as the quantum theory, the electric arc, the structure of crystals, thermionics, etc.

The treatment adopted by the Duc de Broglie is a revelation of the amazing achievements of the X-rays in atomic physics, and provides many indications of the ramifications of the subject into many departments of physics and chemistry. For example, the opening pages contain an attractive discussion of Bohr's theory of the atom, Moseley's law of atomic numbers, and the part the quantum theory plays in the phenomena of radiation.

One is reminded that formerly the X-ray worker was unequipped with a precise means of sorting out the various qualities of X-rays with which he experimented. His only recourse was filtering through metal screens — a method which is relatively crude and ineffective for the purpose, and, indeed, served to mask a number of relations the real meaning of which can only now be appreciated. Nevertheless, by the insight of Barkla and others, several great and general truths were discerned, which laid the foundations of the subject as it has since developed.

A new era dawned with the discovery of the dispersion of X-rays by crystals. The new science of X-ray spectrometry sprang into being and at once turned to account the technique and precision of the older optical spectrometry. Valuable as the work on the analysis of the spectral lines of the optical spectra had proved to be, it was transcended in simplicity and potency by the newer spectrometry. To the literature on X-ray spectrometry the Duc de Broglie has himself contributed in notable measure, and his account of the subject is correspondingly "alive" and authoritative.

Among much that calls for comment in this book is a good account of a variety of metal X-ray tubes which have so far been used chiefly in spectrometry. The recent researches which have filled the gap of 4 octaves between the former boundaries of the ultra-violet spectrum and the X-ray spectrum receive full attention.

One of the more recent triumphs of X-rays in the field of atomic physics is the work of the Duc de Broglie on the speed of the secondary electrons excited when X-rays fall upon matter. The speed was displayed by the method of the "magnetic spectrum"; and using X-rays of a specific wave-length, de Broglie was able to show that the secondary electrons arranged themselves into well-defined groups which had been ejected respectively from the K, L, M, etc. rings of the atoms of the material. These results, which receive simple explanation on the quantum theory and that of Bohr, have been confirmed in Great Britain by Whiddington, and widely extended at the Cavendish Laboratory by Ellis, who used radium γ-rays of much shorter wave-length than can at present be generated artificially. The present volume contains an interesting account of these enthralling investigations.

There are many valuable tables of wave-lengths, etc. in the book, and a number of plates showing some fine examples of X-ray emission and absorption spectra. At the end of each chapter there is a good bibliography. In accordance with French custom there is no index, but tradition is scouted by the provision of a serviceable stiff cover, a feature which will make its appeal in other countries.

G. W. C. KAYE.

Elementary Zoology.

Essentials of Zoology for Students of Medicine and First Year Students of Science. By Prof. A. Meek. Pp. xii+325. (London: Longmans, Green and Co., 1922.) 10*s*. 6*d*. net.

THE volume before us, intended for students of medicine and first-year students of science, is written by one who retains his belief in the "type system," and clearly has no sympathy with those who believe that this method of teaching, unless used with great discretion, is liable to do much to kill the student's interest in his subject.

The book consists of ten chapters, each devoted to one of the more important divisions of the animal kingdom. The chapter on Protozoa commences with short descriptions of Amœba, Paramecium, Vorticella, Cercomonas; these are followed by a section dealing with general considerations such as morphology, physiology, psychology, reproduction, symbiosis; and the chapter concludes with an account of important parasitic types—Opalina, Monocystis, Plasmodium, Trypanosoma. The descriptions of the various types are short and concise, but we notice a number of sentences which are liable to mislead the elementary student: such statements as that the trypanosome "progresses by the action of the flagellum which is *posterior*," that the recrudescence of malarial attacks is due to the female gametocyte developing parthenogenetically, that the fully grown "Plasmodium" becomes crescentic, require qualification or emendation.

The chapter on Cœlenterata deals with Hydra and Obelia, that on Platyhelmia with Distoma and Tænia, that on Mollusca with Anodonta, that on Annelida with Lumbricus and Nereis, that on Crustacea with Nephrops, that on Insecta with Blatta, Anopheles, Culex, and Glossina. We are glad to see our old friend Amphioxus accorded the dignity of a special chapter. The chapter entitled Pisces deals with the skate, and that entitled Amphibia with the frog. This is followed by a chapter on the development of birds and mammals, and the book ends with a chapter on Mammalia, dealing mainly with the rabbit.

As in the Protozoan chapter, so also in other parts of the book, we notice many statements that might with advantage be emended in a new edition. It is not accurate to say the gastrula is a stage in the development of *all* the metazoa. It would be wise to use the word solenocyte in the sense defined by its inventor. The expression "schizocœl *or* mesenchyme" is liable to lead the careless student to think these terms are synonymous. Such statements as "the myocœl develops a sclerotome," "the longitudinal valve [of the frog's conus arteriosus] is disposed in a slightly spiral direction from the right anterior aspect to near the left of the median line posteriorly," "the skeletal muscular system is derived from the . . . *myocœl* of the cœlomic mesoderm," "species of Rana are used for food . . . and large numbers are *employed* in zoological and physiological laboratories" (the italics are ours), are, to say the least, awkwardly expressed.

Such statements as we have quoted indicate that the book would have been the better for more careful revision before going to press. Notwithstanding such blemishes in detail we are of opinion that the book will prove useful to the class of student for whom it is intended. It is illustrated by numerous figures, somewhat rough in execution but for the most part clear and intelligible as well as accurate.

Arabia and Arab Alliances.

The Heart of Arabia: A Record of Travel and Exploration. By H. St. J. B. Philby. In 2 vols. Vol. 1. Pp. xxiii + 386. Vol. 2. Pp. vii + 354. (London: Constable and Co., Ltd., 1922.) 63*s*.

IN October 1917, Mr. Philby found himself the sole representative of Britain in the heart of Arabia on a mission which was organised, with the encouragement afforded by the initial success of the movement against the Turks on the Hejaz, to carry messages of goodwill to the ruling chief of Wahabiland. The co-operation of the latter was to be invited in giving effect to the Euphrates blockade against the Turks, and ultimately to launch a campaign against that very able ally of Turkey, Ibn Rashid of Hail. At the back of it there was no doubt some Utopian ideal of a united Arabia. The ruling chief of Wahabiland (which may be said to include all Najd, or Central Arabia, together with the coast province of Al Hasa bordering the Persian Gulf) was Imam Ibn Sa'ud of Riadh, and it was to Riadh that Mr. Philby's mission was directed, *via* Hofhuf, the capital of Al Hasa, from a port on the Persian Gulf coast opposite Bahrein.

At Riadh, Mr. Philby, who seems able to adapt himself most effectively, not only to Arab clothes, but also to Arab sentiment and the idiosyncrasies of the Arab people, and appears to be perfectly at home in the desert as in the town, secured the friendship of Ibn Sa'ud, and was certainly greatly indebted to that chief for his safety and success while traversing the country. The hospitality and almost invariable expression of goodwill which were extended to him throughout his travels were due not merely to the world-old traditions of the Bedouin but also to the influence of Ibn Sa'ud, who is obviously a most enlightened and competent ruler of a vast territory. At Riadh, Mr. Philby enjoyed the opportunity of giving us an excellent account of the city itself and of the character of the Wahabi faith as professed by its most ardent disciples—all of it most interesting and valuable information. But he failed to meet the British envoy who was to have brought from the west, from the Sharif of Mecca, messages of reconciliation with Ibn Sa'ud, who was known to be bitterly jealous of the Sharif. Nothing, indeed, roused the indignation of Ibn Sa'ud so effectively as that the Sharif of Mecca should assume the title of King of Arabia. All this, of course, is ancient history by this time, and the course of dramatic events which occurred more recently in the Hejaz is modern enough to be within the recollection of most of us. At the time, however, Mr. Philby's immediate movements were determined by the attitude of the Sharif, who simply declined to allow the British envoy to proceed to Riadh. In these circumstances, Mr. Philby decided to go to Taif himself and fetch him. In this, however, he was disappointed, although it led to a journey by the pilgrim road to Jeddah, passing within a measurable distance of Mecca and including a visit to Taif. The Sharif was absolutely hostile to any proposition of alliance with Ibn Sa'ud, and thus fell through the hoped-for unity between Central and West Arabia. Mr. Philby, who gives us a most interesting story of his travel by a route which is little enough known, was obliged to return to Mesopotamia by sea from Jeddah.

It was not long, however, before Mr. Philby found himself once again in Riadh, this time with the object of initiating an active campaign against Ibn Rashid, the Turks' ally at Hail. It was while he was waiting for Ibn Sa'ud to complete the preparations for this expedition (which afterwards proved more or less abortive and involved the death of that brilliant young explorer, Capt. Shakespeare) that Mr. Philby undertook what was by far the most interesting geographical exploration that has been made for many years in Arabia, which carried him as far south as the Wadi Dewasir, nearly to the edge of the great southern desert. He was still within the limits of the Riadh administration, but the influence of it grew weaker the farther he penetrated south, and it was at an important place in the Dawasir oasis, with the ominous name of Dam, that he encountered fanatical hostility, which, but for his tact and energy, might well have brought his career to an untimely end. Many points of especial interest attracted his close attention. The ruins at Kharj, the remains of the tombs of a long-forgotten race, are especially interesting in connexion with those at Bahrein, which were first examined and opened by Durand (Sir Edward of that ilk), whose description of them in the pages of the Journal of the Royal Asiatic Society is far more instructive than that of Theodore Bent (who followed him some years later), and points to a constructive resemblance with those of Kharj which cannot be accidental.

Mr. Philby devotes a chapter to destructive criticism of the delightful romances of Arabian adventure written by William Gifford Palgrave. Apparently he did not previously know (as certainly Mr. D. G. Hogarth, who questions Mr. Philby's conclusion, could not have known) that Palgrave had long been without honour among geographers of the Persian Gulf as a veracious narrator. Palgrave was a Jesuit father, true apparently to the traditions of his order, for, while we must render all honour to those early Jesuit missionaries who were the very first pioneers in the field of Asiatic geography, no one who has endeavoured to unravel their itineraries by the light of more modern determinations can fail to observe their skill in the art of geographical embroidery. We might even repeat Mr. Philby's remark that some of their statements "bear no ponderable relation to fact."

"The Heart of Arabia" must be reckoned as a most valuable addition to the literary efforts that the mysteries of Arabia have called forth. There is always the danger in a work of this sort of descriptive narrative lapsing into the style of the official route report. This is most skilfully avoided by the author in his story of everyday happenings in a society which is as old as that of the patriarchs, and still exists in its patriarchal form. Mr. Philby is much to be congratulated on his remarkable experiences and his manner of telling them.

T. H. HOLDICH.

Our Bookshelf.

Flavouring Materials: Natural and Synthetic. By A. Clarke. (Oxford Technical Publications.) Pp. xxi + 166. (London: Henry Frowde and Hodder and Stoughton, 1922.) 8*s.* 6*d.* net.

THE manufacturer of foods and beverages, whose demands have created the infinite variety of flavouring materials now available, is a person with a remarkably catholic taste, since he appears to take into account anything with a flavour, from aloes to lemons, as possible materials for making his wares attractive. While laying the rose under contribution, he is apparently not averse from keeping scatole in his mind's eye as a possible means of titillating pleasantly the olfactory nerves of his clients. It is quite clear when such unpromising materials as some of these, not to mention colocynth and senna, which the average man regards as particularly nauseous drugs, can be seriously considered as ingredients in foods and beverages designed to be pleasant, that flavouring has become an art which requires its own experts and its own literature.

Mr. Clark's contribution, which he modestly describes as notes accumulated during a number of years' work in a technical capacity in the foodstuff and beverage trades, is a good beginning, and gives within small compass a mass of useful information regarding spices and condiments, the methods used in determining their quality, and the best ways of baulking the wily sophisticator who substitutes ground date or olive stones for powdered cinnamon or ginger. But spices in their natural state are no longer the only materials on which the flavouring expert can draw, and a considerable part of the book is devoted to a summary of the characteristics of purely chemical substances, extracted from essential oils or made in the factory. The particular part they can play in compounding flavours is described, and the things they may or may not be blended with are duly recorded.

The statements regarding each product are reasonably complete, and where further information is required references to original literature are given. Altogether the book is a good example of what technical literature of this kind should be, and though it would be easy to find points in it that are objectionable from a purely scientific point of view, they are not likely to mislead the reader for whom the book has been compiled.

T. A. H.

The Theory of Emulsions and Emulsification. By Dr. William Clayton. (Text-books of Chemical Research and Engineering.) Pp. viii + 160. (London: J. and A. Churchill, 1923.) 9*s.* 6*d.* net.

DR. CLAYTON'S book is a fitting sequel to earlier issues of the series of "Text-books of Chemical Research and Engineering" to which it belongs. These have included volumes on molecular physics, the physics and chemistry of colloids, surface tension, catalysis, and catalytic hydrogenation. The skilful blending of advanced theory with advanced practice which characterises Dr. Clayton's book is therefore by no means a novel feature of these text-books. The author claims that his chief aim has been "to follow a logical line of development based on modern physico-chemical principles," and that "technical applications of emulsions have only been introduced either as illustrating some particular laboratory method on a large scale or because some important theoretical point is involved."

While, however, much of the book is actually devoted to theory, the practical aspects of emulsion-making and emulsion-breaking are very far from being neglected. Indeed, one of the most striking features of the later chapters is the large number of references to patents covering processes for carrying out these contrary operations. One of the most important applications of the process of emulsion-making is the homogenising of milk and cream. A process whereby new milk of 4 per cent. fat content acquires the appearance of a cream containing 8 per cent. fat, while a 15 per cent. cream becomes a good substitute for a 25 per cent. cream, has obvious attractions. The opposite process of breaking emulsions is an important operation in the initial treatment of crude mineral oils; but it is also important in the de-oiling of condensed steam, as well as in the more familiar operation of separating cream from milk and converting it into butter. The book contains a bibliography of nearly 200 papers dealing with emulsions and marks a new era in the scientific study of a subject which has very important practical applications.

T. M. L.

Mathematics for Students of Agriculture. By Prof. S. E. Rasor. Pp. viii + 290. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd., 1921.) 16*s.* net.

EVERY indication that mathematics is assuming a more prominent position in the curriculum of students of agriculture is very welcome. The mathematical requirements of the agricultural student are roughly twofold. First, he requires a knowledge of simple calculations applicable to the routine problems of fertilisers, feeding stuffs, surveying, buildings, book-keeping, etc. Secondly, he very urgently requires an elementary understanding of statistical methods and probabilities applicable to the interpretation of experimental results. Prof. Rasor's book deals mainly with the first of these requirements. The value of the book to agricultural students approaching mathematics for the first time would be enhanced if less prominence were given to formal definition and more to simple explanation, but there is no doubt about the usefulness of this book to the student who wishes expeditiously to revise and amplify previous work. It is concise, well indexed, and contains a large number of exercises. Some of the latter might profitably be revised. The statement in Exercise 5 on p. 13 that in a certain fertiliser "$43\frac{3}{4}$ per cent. is phosphoric acid (phosphorus)" will doubtless annoy the chemist. In the same exercise the student is asked to calculate how much acid phosphate containing 16 per cent. phosphoric acid is required, when mixed with cotton seed meal and kainit, to provide a mixture containing $43\frac{3}{4}$ per cent. phosphoric acid. A practicable answer to this question might be the salvation of agriculture.

Unfortunately the use of American data and money units detracts from the value of the book to students elsewhere. N. M. C.

(1) *A Canadian School Geography*. By Prof. G. A. Cornish. Pp. xiv+450. n.p. (2) *The Canadian School Atlas*. Prepared at the Edinburgh Geographical Institute under the Editorship of Prof. G. A. Cornish. Pp. v+65 maps+16. n.p. (Toronto: J. M. Dent and Sons, Ltd., 1922.)

(1) THE best features of this work are the maps, illustrations, and practical exercises. For the rest the book is planned on somewhat orthodox lines. Too much is attempted in the space available, so that in places the book gives little more than a catalogue of uncorrelated facts. It is certainly most informative, especially with regard to Canada, to which a large part of the book is devoted, but on the whole the geographical outlook is wanting.

(2) The atlas was prepared in the first instance to be used with this text-book, but may easily make a wider appeal as a general reference atlas for use in Canada. It contains forty-eight pages of finely executed maps by Bartholomew and a full index. Fourteen pages are devoted to maps of Canada, of which the most populated parts are shown on scales of 1 : 2,500,000. The rest of the world is shown on small-scale maps, but there is a coloured orographical map of every continent. One improvement would be the addition of a larger scale map of India, but the atlas as a whole deserves high praise.

Nyasa, the Great Water: being a Description of the Lake and the Life of the People. By the Ven. William Percival Johnson. Pp. vii+204. (London: Oxford University Press, 1922.) 7*s*. 6*d*. net.

IN this volume, the Archdeacon of Nyasa has placed on record his knowledge of the lake and its people, among whom he has served for many years as a member of the Universities' Mission to Central Africa. In the preface, the Bishop of Oxford, with pardonable enthusiasm, says that it is unique and "a book which no student of 'backward' races can afford to leave unread." Its readers, perhaps, will not be prepared to go so far; but it is certainly a valuable and intimate study of the life and mentality, the customs, occupations, and beliefs of the Angoni, Wa Yao and Nyasa or Nyanza who live on the shores of the great lake Nyasa. The salient feature of the book is its keen insight into the native mind—a result which is achieved most markedly by means of the chapter of "village stories," in which the author has reported, in the words of the natives themselves, incidents of courage and helpfulness in the face of known and concrete danger. These he contrasts with the fear, leading to cruelty, arising out of the impalpable and unknown, which lies at the root of much of their religious ritual and belief.

Into the East: Notes on Burma and Malaya. By R. Curle. Pp. xxxi+224. (London: Macmillan and Co. Ltd., 1923.) 10*s*. net.

"CITIES (like persons)," says the author of this work, "have their idiosyncrasies that, slowly revealing themselves, layer upon layer, absorb you at last into their atmosphere," and goes on to ask what it is that the new-comer feels about Rangoon, in this particular instance, that to an inhabitant is second nature. Wherever his travels in the East have taken him, his purpose has been to seize the essentially differentiating quality in each place. He speaks of his book as a record of things seen and of things thought; but in the mind of the reader the latter will loom larger than the former, and in the retrospect, whether the author's words describe Colombo, Rangoon, Mandalay, the mining town of Kuala Lumpur, or the investiture of the Sultan of Perak with the K.C.M.G., it is their quality as an intensely personal record of impressions rather than as a statement of fact that will remain. In the end the author confesses himself baffled by the East, and its inscrutability and aloofness is perhaps the most vivid of the impressions he conveys to his readers. Mr. Joseph Conrad contributes a preface in which he discourses in characteristically alluring manner of travellers and of their works.

Abrégé de géographie physique. Par Prof. E. de Martonne. Pp. v+355. (Paris: Armand Colin, 1922.) 15 francs.

STUDENTS of geography will be glad to have this outline summary of M. de Martonne's well-known "Traité de géographie physique." The general plan is the same as in the larger work, but a new chapter has been added giving a sketch of the relations of human and physical geography. In order to make the treatment throughout the book as concrete as possible, the author has chosen under each heading the most striking aspects of the subject, wisely making no attempt to cover all the ground in a limited number of pages. The third section, "le relief du sol," is particularly lucid, and is illustrated by most instructive photographs and block diagrams. The bibliographical references to each section are well chosen, but why is there no index?

The Practical Electrician's Pocket Book for 1923. Twenty-fifth Annual Issue. Edited by H. T. Crewe. Pp. xci+571+Diary. (London: S. Rentell and Co., Ltd., 1923.) 3*s*. net.

A CHAPTER on "wireless" broadcasting has been added to this useful little book. Apparently some experimenters have difficulty in getting a good "earth," but the suggestion that they should get an old bath, solder the earth wire to it and then bury it, is in our opinion quite unnecessary.

Letters to the Editor.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, nor to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Quantum in Atomic Astronomy.

THE approach to the quantum by the path of energy, though historically natural and probably inevitable, is scarcely the simplest mode of presenting it to students. So long as assumptions or guesses have to be made, as a supplement to ordinary dynamics when applied to events occurring in the interior of an atom, it is best to make them nakedly, so as not to cloak their character; and then to let experience justify them, and hope for subsequent theory to explain them. This is a procedure after the manner of Kepler. The following brief summary, though inadequate as an exposition, is sufficient to indicate the main points in what I imagine to be a slightly clarified mode of presentation.

Bohr assumed (virtually) that, in a family of electrons revolving round a nucleus, the rate of sweeping areas, $r^2d\theta/dt$ or $r^2\omega$ constant for any one orbit, proceeded discontinuously in arithmetical progression from orbit to orbit. This supplied a kind of Bode's law for the succession of satellite electrons, not at all dissimilar from the actual rough succession of planetary orbits round the sun provided that some of the possible orbits may be left empty; as they conspicuously often are inside the atom.

The recognised expression for twice the rate of sweeping areas, for inverse-square motion round a centre of force, is

$$\sqrt{\mu a(1-\epsilon^2)};$$

and this, multiplied by the mass of the revolving particle, is its moment of momentum mpv, with p the perpendicular on the tangent; also called angular momentum, $mr^2d\theta/dt$.

Bohr's assumption is that in the atom this quantity can only exist discontinuously in indivisible units or atomic portions, say A, of which only integer multiples are possible; so that it equals nA. One would gladly use the letter h for twice the rate of describing areas, as usual, had not the symbol been otherwise monopolised, in this connexion, by a quantity which, though approached differently, turns out on arrival to be nearly the same.

Our first equation, then, is that

$$m\sqrt{\mu a(1-\epsilon^2)}=n\text{A}.$$

The time period of an inverse-square orbit is well known as

$$\text{T}=2\pi\sqrt{\frac{a^3}{\mu}};$$

and this is our second equation.

So, combining these two equations, and ignoring the excentricity ϵ as an unimportant and provisional detail, we get at once for the angular velocity in a permissible circular orbit,

$$\omega=\frac{2\pi}{\text{T}}=\frac{\mu^2m^3}{n^3\text{A}^3};$$

μ being, as usual, the force intensity, or acceleration at unit distance, namely in the electrical case, Ee/m, or $r^3\omega^2$. For accuracy, m should be interpreted throughout as half the harmonic mean, M$m/(\text{M}+m)$, because the revolution is round the common centre of gravity.

But, in accordance with Bohr's assumption, $n\text{A}=mr^2\omega$; so that $n\text{A}\omega$ is energy, mv^2, or say 2W.

Energy is therefore proportional to frequency; and we can proceed to identify Aω with Planck's $h\nu$, and find that the relation between the introduced constants is simply $h=2\pi\text{A}$, because $\omega=2\pi\nu$.

Further, by remembering that whenever a particle falls in towards an inverse-square centre of force it gains twice the energy which it can retain in a circular orbit (though no dynamical reason can be given for its half-stopping and occupying such an orbit and ejecting its surplus energy), we get for the energy radiated, on Bohr's second assumption that radiation only occurs when electrons drop from orbit to orbit, the difference between $\frac{1}{2}n_1\text{A}\omega_1$ and $\frac{1}{2}n_2\text{A}\omega_2$; or

$$\text{W}_1-\text{W}_2=\frac{\mu^2m^3}{2\text{A}^2}\left(\frac{1}{n_1^2}-\frac{1}{n_2^2}\right).$$

Whence Rydberg's spectrum-frequency-constant, defined as the constant part of $\delta\text{W}/h$, comes out in the alternative forms,

$$\text{N}=\frac{\mu^2m^3}{2\text{A}^2h}=\frac{2\pi^2\text{E}^2e^2m}{h^3}=\frac{\text{E}^2e^2m}{4\pi\text{A}^3};$$

of which the last seems to have some advantages.

OLIVER LODGE.

The Resolving Power of Microscopes on Test-plates for Microscopic Objectives.

IN letters published in NATURE (September 1, 1921, p. 10; February 16, p. 205, and May 27, 1922, p. 678) on the above-mentioned subjects, I gave an estimate of the limit of microscopic resolving power; that is, of the least distance which must exist between two points in the focal plane if they are to appear as separate points in the image. I mentioned half a wave-length of the illuminating light as its approximate value. I have now, however, reason to believe that this is an overestimate and that $0{\cdot}7\lambda$ is nearer the mark. This is in agreement both with a re-computation of the illumination near the image of a point and with observations made on the test plates.

The image of a bright point in the geometrical focus of a lens consists, as is well known, of a bright disc surrounded by rings, the dark spaces between which indicate the positions where the integral difference of the optical length of the rays from any part of the dark ring to the corresponding distance from the geometrical focus is half a wave-length.

In Fig. 1 let O be the geometrical focus and $O\gamma$ the axis of the lens. Let SS' be a section of the spherical wave surface which by the action of the lens is converted into a second spherical surface with the same axis and with its centre at the conjugate focus. Let P be a point in the focal plane near O, and divide the surface SS' into elementary zones by planes to

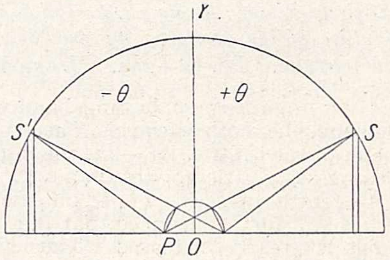

FIG. 1.

which OP is normal. Consider a pair of such zones in latitudes $+\theta$ and $-\theta$ (taking the diametral plane as equatorial). Every point in each zone is at a constant distance from P, and the constant difference between PS and PS' is $2OP\sin\theta$. Assuming that the focal length OS is great compared with λ, and the conjugate focal length great compared to OS, then the difference of phase in the waves contributed to the image by each pair of zones is (if $OS=r$) $4\pi(r/\lambda)\sin\theta$. Putting A for the wave amplitude which would exist in the image if all the partial waves arrived in the same phase, and writing ϕ for $4\pi(r/\lambda)\sin\theta$, the actual amplitude at the geometrical conjugate focus of a point distant r from O is $A\int_{\theta_2}^{\theta_1}\cos(\phi/2)d\theta$, where θ_1 and θ_2 define the operative areas of the wave surface SS'. The value of A will be different for each pair of limits, but the ratio between the amplitude at O and that at r is $\int_{\theta_1}^{\theta_1}\cos(\phi/2)d\theta$. In computing this integral a table was formed for $\cos\phi/2$ between the limits 0 and 2 for r/λ, and 0 and $\pi/2$ for θ. Fair curves were drawn through the plotted values of $\cos\phi/2$ for each of the chosen values of θ (see Fig. 2)

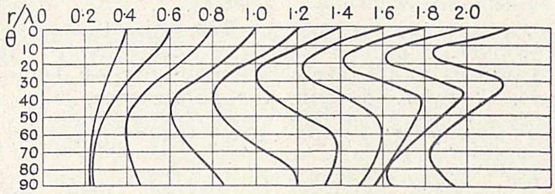

FIG. 2.—Horizontal lines measured from the curves to each of the principal verticals are the values of $\cos\phi/2$ (where $\phi=4\pi(r/\lambda)\sin\theta$) from $\theta=0$ to $\theta=\pi/2$, and the principal verticals refer to values of r/λ from 0 to 2.

and the algebraic area of the curves for various limiting values of θ was measured with a planimeter[1] (see Fig. 3). The intensities of the illumination are of course as the square of the amplitude.

When two or more luminous points in the focal plane are in proximity, the interference effects occurring between their ring systems are not independent of the nature of the illumination. If the luminous points radiate light proceeding from a single source, there is a definite phase relation among the emitted waves, and in this case the intensity is proportional to the square of the sum of the amplitudes; if, however, the points are self-luminous it is the sum of the squares which must be taken.

The change in the appearance in the field of a microscope when a point source is substituted for diffused light is very conspicuous.

The curves in Fig. 3 indicate that as the aperture of the lens is increased from 0 to 90° the diameters of the central disc and of the rings are reduced, as well as the relative brightness of the rings, and that when the whole hemisphere of the wave surface is operative the diameter of the central disc—*i.e.* the radius of the first dark ring—is a little greater than $0{\cdot}4\lambda$.

When the central rays are stopped out the diameter of the disc is still further reduced, but the brightness of the rings is greatly increased. Thus when only the marginal rays are effective the image of a single line will appear multiple.

It must be remembered that these curves only apply to points in the focal plane, and that the radii of the rings for points slightly out of focus are greater. The lateral spectra which accompany the image of lines (which may be regarded as the envelope of the ring systems of a series of points) have a considerable effect on the appearance seen in the field of the microscope.

It is usually held that an object is in focus when the definition is sharpest. This, however, is not

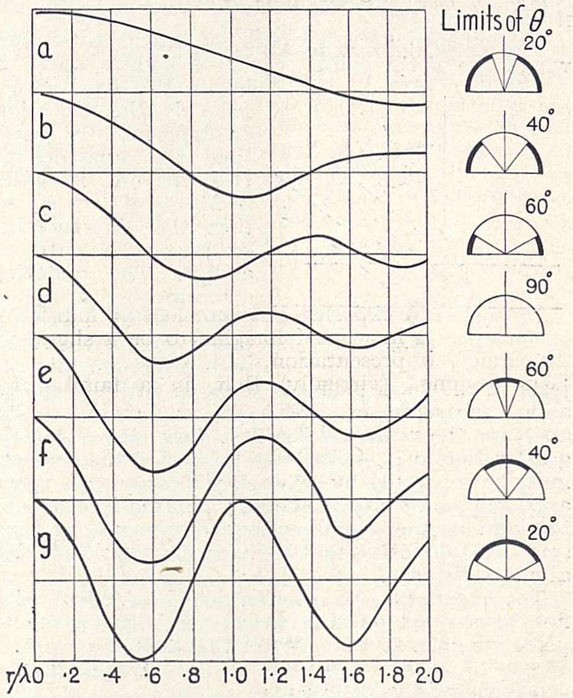

FIG. 3.—The curves are the algebraic integrals giving the areas included between the curves and verticals in Fig. 2 for each value of r/λ, and between the limits for θ indicated on each of the diagrams, namely:

Diagram	θ_1	θ_2			
a	20°	0	d	90°	0
b	40°	0	e	90°	20
c	60°	0	f	90°	40
			g	90°	60

The ordinates of the curves give the amplitudes of the resultant vibrations (expressed as fractions of the amplitude at the geometrical focus) at the various values of r/λ.

really the case. If bands of fine ruling in close proximity to one another are examined, it will be found that a separate adjustment of focus has to be made for each and that the best result is obtained when the focal adjustment makes the spacing of the lateral spectra the same as that of the lines of each band.

With ordinary test objects (diatoms, engraved lines, etc.) this effect is somewhat disguised owing to the thickness of the objects themselves, which is quite comparable to the wave-length, but in such test plates as I have described in my former letters, where the thickness of the film on which the lines are ruled is only 1/15 to 1/30 of a wave-length, the question of thickness does not arise.

The high resolving power which has been attained on diatoms and engraved lines should be attributed to variations of thickness in the objects, as these increase the rate at which the length of the optical path changes for points near the geometrical focus; *i.e.* for the variation of r. It is customary to mount such objects in media of high refractive index, which has the effect of exaggerating the optical depth of the grooves, etc., and it is worth notice that if an object has no thickness, or a thickness small compared to the wave-length and the only characteristic of which is a difference in opacity from place to place, the refractive index of the mounting medium is without effect on

[1] For a somewhat similar purpose Airy (see his "Intensity of Light in the neighbourhood of a Caustic," Camb. Phil. Trans., vol. 6, pp. 379 *et seq.*) computed his table numerically by methods much more accurate, but also much more laborious, than the planimeter. The latter, however, is sufficiently good for the purpose of this note.

the resolving power. In Fig. 4 let O and P be points in the focal plane. If the surrounding medium is air the optical length of the rays from O and P differ by $OP \sin\theta$. If O and P are covered by a uniform layer of a medium the refractive index of which is μ, the same rays in the medium make an angle θ' with the axis, where $\theta' \sin\theta' = \sin\theta/\mu$. The difference of optical length is then $OS\mu \sin\theta' = (OS\mu \sin\theta)/\mu = OS \sin\theta$, as it was in air.

This independence of μ does not extend to the case where one of the points O or P is slightly above or below the focal plane. If h is the elevation or depression in question, the difference of the optical lengths is $h(\mu \cos\theta' - \cos\theta)$, so that the difference increases both with μ and h. The quantity $0{\cdot}7\lambda$ suggested above as a limit to the resolving power of microscopes with respect to thin objects in the focal plane is a guess rather than an actual measurement. With the maximum angular aperture the radius of the first dark ring is a little greater than $0{\cdot}4\lambda$, which would indicate that objects must be separated by $0{\cdot}8\lambda$ before a really dark space appeared between their images; but the intensity of the light in the neighbourhood of the ring is very small, and doubtless the objects would seem as double at a less distance.

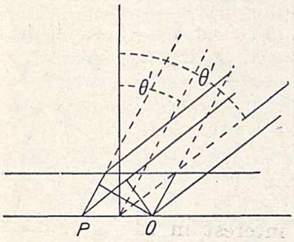

Fig. 4.

The experience, however, which I have had with fine lines ruled on thin films would induce me to place the limit at more, rather than less, than $0{\cdot}7\lambda$.

A. Mallock.

9 Baring Crescent, Exeter,
May 19.

The Fluorescence of certain Lower Plants.

It will, I venture to believe, interest some of the readers of Nature to know that the Cyanophyceæ (Schizophyceæ) or blue-green algæ, the diatoms and some at least of the true green algæ among, or closely related to, the Pleurococcaceæ, are visibly strongly fluorescent when viewed ultramicroscopically, if the proper optical conditions are achieved. A much wider claim for the usefulness of the method might be made, but it will be unnecessary; for the moment, if any one who may be interested tries it, he will appreciate at once its many possibilities.

The optimum conditions are these: a dark-field condenser, preferably of the cardioid type, *thin* glass object-slides (0·8 mm. thick or less), preferably thin covers and a *dry* objective of any magnification. Water between the upper lens of the condenser and the slide answers every purpose, and is much more comfortable in extensive ultramicroscopy. The best light source, when one is studying colour, and this becomes of prime importance in this connexion, is a small arc; but generally speaking, a condensed filament, 400-watt lamp with a suitable condenser, answers every purpose. The thin object-slide and the glass-air interface of the cover are the essential features, since one is then able to focus the *reflected* hollow beam of light from the upper surface of the cover glass upon the object. It will be seen that in using the dark-field condenser in this manner we are reviving the idea embodied in the "spot lens" of Thomas Ross, in Wenham's air paraboloid (1850) with a similar spot lens, and in his glass paraboloid condenser of 1856 (Siedentopf, H., "Die Vorgeschichte der Spiegelkondensoren," *Zeitschr. f. wiss. Mikroskopie*, 24: 382-395, 1907). As these could be used only with a dry objective, the later effort was aimed at the result achieved in our present apparatus. It is evident from current published directions of manufacturers for work with the dark-field illuminator that the use of the reflected light cone is not contemplated. I refer especially to the specifications as to object-slide thickness. While not having the advantage of the magnification afforded by the oil-immersion, we gain very greatly in many features of the object-picture afforded.

One of the most important of these is that the blue-green algæ, when seen at the apex of the light cone inverted by reflection, afford their fluorescence colours. Some species are more readily recognised to fluoresce than others, but if the material be mounted in strong glycerin, thus obviating the scattering of light by internal surfaces either in the organism or in the surrounding mucilage, the cells are then seen to glow with a fervid light, orange or crimson according to the organism. Indeed, when glycerin is used, the fluorescence can be seen without making use of the inverted light cone, just as, according to Siedentopf, bacteria lightly coloured with a fluorescent stain ("Über Beobachtungen bei Dunkelfeldbeleuchtung," *Zeitschr. f. wiss. Mikroskopie*, 25: 273-282) may be seen with oil-immersion objectives. The object-picture then afforded has advantages of its own which need not be detailed here. Without glycerin, the fluorescence, even of those species which are most readily observed in this respect, is scarcely visible with oil-immersion objectives.

When seen mounted in glycerin, then, some species of Oscillatoria are crimson, as also are Cylindrospermum, *Anabæna Azollæ*, some species of Nostoc and of Chroococcus, Rivularia, and others; while other species of Oscillatoria and Nostoc are golden orange. *Chroococcus refractus* (I do not assert positive identification) appears a dull yellow, all these forms affording a most striking contrast to their appearance by transmitted light, that with which students of them are familiar.

I have found evidence that the pigment is in solution in minute vesicles (supporting in part Wager's conclusions, Proc. R.S., 72: 401, 1903). With death, it becomes adsorbed by the cytoplasm and the cells then appear blue (*e.g.* Nostoc). On examining material of *Nostoc commune* from China, which I have had in my possession some twenty years, I found the cells as strongly fluorescent as if fresh. The stiff gelatinous sheath appears light blue, perhaps also from adsorbed phycocyanin. When freshly mounted in glycerin, blue-greens hold their fluorescence for some time. I have an Oscillatoria kept thus for twenty days without loss of fluorescence. The old *Nostoc commune* lost its fluorescence in less than twenty-four hours, perhaps because it was already dead.

I have shown that the fluorescence is due to phycocyanin, rather than to chlorophyll, which, because of the "colloidal condition" in which it occurs in the living cell, has not been found visibly fluorescent. E. Raehlmann ("Neue ultramikroskopische Untersuchungen über Eiweiss," etc., *Pflüger's Archiv ges. Physiologie*, 112: 128-171, 1906), it is true, thought that he could see chlorophyll fluorescence with the ultramicroscope, but he used suspensions or emulsions, and with these I have obtained similar results. With suitable means, the fluorescence microscope, for example, the fluorescence of the living chloroplast can be observed, but one can scarcely persuade oneself that it can be seen with the ultramicroscope as ordinarily used. One can, I think, see a dim suggestion of the fluorescence colour in isolated chloroplasts (Elodea), and in the chloroplast of Spirogyra, but when *in situ* the multitude of reflecting surfaces produces so much transmitted light that the fluorescence is masked by the green coloration.

It was, therefore, of no small interest to find also that the pigment in the oil vacuoles of the diatoms, pale greenish-yellow by transmitted light, is also visibly deep red fluorescent when viewed in the manner above described. Glycerin must be used as a mounting medium. Examined thus, the fluorescent pigment is seen to fill vacuoles, large and small. I have found that this pigment is not destroyed at the temperature of boiling water, whereas phycocyanin changes at about 60° C. irreversibly, and loses its fluorescence. It may be the phycocyanin-like pigment found by Bocat (through Czapek, "Biochemie des Pflanzen," 1 : 601) in Navicula, which, as a matter of fact, has two large fluorescent vacuoles and usually two small ones, one near each end of the cell.

Scenedesmus glows with a deep red light, as also a small species of Raphidium (or closely similar organism). I have found further evidence of fluorescence in other green forms, notably an ulvaceous one.

Many beautiful results will reward the microscopist who will use the method. Especially, one can scarcely contemplate the remarkable irradiance of these lowly plants without realising anew the importance of the problem of the physiological significance of fluorescence. In a paper presented at the recent meeting of the Royal Society of Canada, I have endeavoured to discuss the matter in its more general bearings. The immediate purpose is to direct attention to a means of increasing the usefulness of the dark-field condenser.

FRANCIS E. LLOYD.
McGill University, Montreal, June 1.

Dr. Kammerer's Lecture to the Linnean Society.

I AM very sorry to differ from my friend Prof. MacBride, but it is impossible for me to agree with some of his remarks on Dr. Kammerer's recent lecture (NATURE, June 23, p. 841). I did not assert that Dr. Kammerer made "childish mistakes which would disgrace a first-year student in biology." I expressed my opinion that it was not correct to state that the ovary of Salamandra is enclosed in a membrane while that of the bird is not. I fail to see why Dr. Kammerer's statement should require to be translated into modern technical language. It is a somewhat serious suggestion that he cannot express his ideas in such language for himself, and if that be so, it supports my criticism that in some respects his statements were not in accordance with the present state of biological knowledge.

I cannot, however, accept even Prof. MacBride's description of the condition of the ovary of the bird as correct (and I dissected out the ovary of a common hen to-day, not for the first time). The ovary of the bird is almost as completely invested by peritoneum as that of the Salamander, not only on its ventral surface but on its lateral surfaces also, and it is not largely retroperitoneal. I agree that the ovary of the bird is more difficult to remove in its entirety, because it is sessile on the peritoneum, and not connected with it by a membrane, and still more because its attachment is close to the great post-caval vein, so that it is difficult to remove the part by which it is attached without cutting into the vein. To be strictly correct, the narrow membrane which attaches the ovary to the wall of the body cavity in Salamandra is not a mesentery, as Prof. MacBride calls it, because that term means a membrane connected with the intestine.

It would serve no useful purpose to reply to other points in Prof. MacBride's letter. He refers me to Dr. Kammerer's "long paper." But I was dealing with the lecture as delivered and printed, which in my opinion failed to show that Dr. Kammerer had an adequate conception of the range of knowledge, the completeness of evidence, and the validity of reasoning, required to establish the conclusions he asks us to accept. I am not, of course, suggesting any deception on Dr. Kammerer's part—except self-deception. Lamarckian doctrine has often suffered more from the indiscretion of its advocates than from the attacks of its enemies.

J. T. CUNNINGHAM.
East London College, Mile End, E.1,
June 26.

The British Journal of Experimental Biology.

THOUGH British workers have made some of the most signal contributions to the morphological aspects of zoology, and names like those of Romanes, Bateson, Doncaster, and Geoffrey Smith will always be distinguished for pioneer discoveries in the experimental field, Great Britain at the present moment compares very unfavourably with other countries in facilities for the publication of researches in experimental biology, especially on the zoological side. There is no single journal devoted wholly or mainly to the subject, with the exception of the *Journal of Genetics*, which of course only covers a portion of the field. We have in Great Britain nothing to compare, for example, with the *Journal of Experimental Zoology*, the *Biological Bulletin*, and the *Journal of General Physiology* in America, or with the *Archiv für Entwicklungsmechanik* in Germany and the French *Archives de morphologie expérimentale*. Nor have we any biological journal which makes it a regular practice to publish articles of a general nature summarising and discussing critically recent additions to knowledge, as in the *American Naturalist* and the *Referaten* of several continental journals.

In the absence of an adequate medium of publication in Great Britain, experimental biologists do not know sufficiently what work is in progress, with the natural result that there is overlapping; that experimental inquiry, lacking a satisfactory channel of expression, may fail to exert an influence essential for the further development of biology in Great Britain; and that younger men will tend to migrate from the zoological laboratories to associate themselves with departments of human physiology. Biological science is at present passing through a period of transition: on one hand, it is becoming increasingly clear that the problems of evolution can no longer be dealt with adequately from the traditional morphological and descriptive point of view of zoology; on the other, the adoption of experimental methods by the general zoologist is opening up new fields of research and making it possible to study more readily the nature of many fundamental biological processes, such as fertilisation, development, sex and heredity, which have been too often neglected by traditional physiology. In the words of a distinguished morphologist, there is a growing tendency "to return to the practice of earlier days, when animal physiology was not yet divorced from morphology."

We believe that the time has now come when it is possible to issue a British journal devoted to general biology, in particular to experimental research and to investigations bearing directly upon experimental problems. We have, therefore, arranged with Messrs. Oliver and Boyd, Edinburgh, to undertake the publication of the *British Journal of Experimental Biology*, the first number of which will appear in September next. The new journal will receive communications in comparative physiology, experimental embryology, genetics, and animal behaviour, as well as cytological, morphological, and histological contributions bearing on current experimental problems. It will also publish by invitation authoritative résumés of recent progress in various fields of inquiry. Any relevant original contribution will be considered for publication.

Inquiries may be addressed to the Animal Breeding Research Department, the University, Edinburgh.

F. A. E. CREW.
W. J. DAKIN.
J. HESLOP HARRISON.
LANCELOT T. HOGBEN.
J. JOHNSTONE.
F. H. A. MARSHALL.
GUY C. ROBSON.
A. M. CARR SAUNDERS.
J. McLEAN THOMPSON.

An Einstein Paradox.

THE fallacy of the argument put forward by Prof. R. W. Genese, in the former part of his letter in NATURE of June 2, p. 742, lies in his supposing that the time t at which K sees the light-signal from L is related to the time t', when K_1 sees the same signal, by the transformation

$$t' = \beta(t - vx/c^2),$$

where $$\beta = (1 - v^2/c^2)^{-\frac{1}{2}}.$$

If we suppose the light-signal to be emitted from L at a time T (in K's system) and T_1 (in K_1's system), then

$$T_1 = \beta(T - vx/c^2), \quad . \quad . \quad . \quad . \quad (1)$$

$$x_1 = \beta(x - vT), \quad . \quad . \quad . \quad . \quad (2)$$

where $x = KL$, $x_1 = K_1L$.

Suppose now that K receives the signal at time t (in his system) and that K_1 receives it at time t_1' (as judged by K_1's system). Let t_1 be the time in K's system corresponding to t_1' in K_1's system. Then

$$t = T + x/c, \quad . \quad . \quad . \quad . \quad (3)$$

$$t_1' = T_1 + x_1/c, \quad . \quad . \quad . \quad . \quad (4)$$

and $$t_1' = \beta(t_1 - vx/c^2). \quad . \quad . \quad . \quad (5)$$

Substitution from (1) and (2) in (4) gives, with (3),

$$t_1' = \beta t(1 - v/c),$$

and comparison with (5) shows that $t \neq t_1$.

A little careful consideration of these equations will now show that the supposed paradox does not arise for the case $x_1 = 0$. J. T. COMBRIDGE.

King's College, Strand.

Multiple Temperature Incubator.

IN the course of some experimental work on insects which we have been carrying out, it was necessary to have a large number of constant temperatures. As it was impossible to have a complete incubator for every temperature, an incubator was designed by Mr. T. W. Kirkpatrick and myself to give a continuous series of constant temperatures.

The principle used is the conduction of heat along an insulated metal bar between two constant temperatures. In practice one of these is an ice-box and the other a hot water bath at any convenient temperature. Between the two is a bar, tube, or trough of metal, four to twelve feet long, which has holes bored at close intervals throughout its length. Both copper and aluminium have been used for the conducting bar. The whole is well insulated to avoid the influence of the daily temperature change.

The apparatus has exceeded our expectations and would probably be of great use to investigators in other fields. Full details with scale drawings and temperature charts will be published shortly in a Bulletin of the Ministry of Agriculture of Egypt, which will be sent to any one who is interested.

C. B. WILLIAMS.
Ministry of Agriculture (Entomological Section),
Cairo, June 20.

Phosphorescence caused by Active Nitrogen.

IN order to prepare aluminium chloride for atomic weight determination, I burnt pure aluminium metal in a current of pure dry chlorine. Before starting the reaction, pure dry nitrogen was passed through the apparatus to expel the air. After this has been attained, the flow of nitrogen was stopped and a slow current of pure dry chlorine was allowed to pass over the metal. Since the pure dry gas reacts very slowly with aluminium at ordinary room temperature, the tube containing aluminium was heated to about 500° C. After the completion of the reaction, the aluminium chloride formed and a quantity of uncombined metal was cooled in a very slow stream of nitrogen. As the red heat ceased, a bright green phosphorescence appeared in the reaction tube surrounding small pieces of corroded uncombined metal.

This phenomenon was excited the next day when the synthesis was continued, and the last traces of chlorine were removed by nitrogen. In both cases the afterglow disappeared after about one minute. Two important facts should be added, namely:

(1) The reaction tube—free of chlorine—with aluminium chloride and the metal was heated again to the same high temperature, and nitrogen was passed over while the whole system was cooling down. The bright green light did not appear. Nothing of this kind of light was visible when the pure metal was heated alone. This is a sufficient proof that the observed afterglow in the former cases was not caused by a trace of any known or unknown impurity of the metal used.

(2) The phenomenon was not observed during the synthesis of aluminium bromide which was carried out by Prof. Th. W. Richards and me in the same manner, and with an aluminium of the same origin.

In NATURE of May 5, p. 599, and May 26, p. 705, were published letters by Prof. E. P. Lewis and Mr. W. Jevons describing phosphorescence caused by active nitrogen. These letters, particularly the second, by Mr. W. Jevons, suggested to me that the afterglow of aluminium left in the reaction tube was very probably caused by active nitrogen. The presence of traces of active nitrogen was caused by the violent reaction of the chlorine left in the tube with the aluminium metal. This reaction activated some of the nitrogen passed over the metal. When, however, all the chlorine was expelled and the contents of the reaction tube were heated as in the case described above, no phosphorescence appeared. H. KREPELKA.

Department of Inorganic Chemistry,
Charles' University,
Prague, Czechoslovakia.

The Cryogenic Laboratory of the University of Toronto.

By Prof. J. C. McLENNAN, F.R.S.

SHORTLY after the commencement of the War it became evident that if helium were available in sufficient quantities to replace hydrogen in naval and military airships, losses in life and equipment might be very greatly lessened.

It was known that there existed in America supplies of natural gas containing helium in varying amounts, and Sir Richard Threlfall, as a result of preliminary calculations that led him to believe that this helium could be extracted at a cost that would not be prohibitive, proposed that the Board of Invention and Research of the British Admiralty should undertake an investigation of the matter. As a result of this proposal the writer was asked by the Board to determine the helium content of the natural gases of Canada. This survey was carried out in the winter of 1915–16, and it was found that from 10,000,000 to 12,000,000 cubic feet of helium could be obtained per year from the natural gas of the Bow Island supply near Calgary, Alberta.

In the autumn of 1917 the Admiralty sanctioned proposals to proceed with an attempt to extract this helium, and in the summer of 1918, after exhaustive experiments had been made, a plant was designed for the purpose. This apparatus was constructed and installed at Calgary and was operated from September 1919 until April 1920. In the course of this operation of the plant, considerable supplies of helium of high purity were obtained and it was shown that the estimates of Sir Richard Threlfall as to the cost of production were amply verified.[1]

During the winter of 1919–20 proposals were put forward by the writer to use the helium extracted at Calgary for scientific purposes. These met with approval, and financial grants were made for the liquefaction of helium by the Honorary Advisory Council for Scientific and Industrial Research of Canada, by the University of Toronto, and by the Carnegie Foundation for Research. Some apparatus was also loaned by the Admiralty and by the Air Ministry of Great Britain. With these grants special apparatus for liquefying air, hydrogen, and helium was constructed and its installation in the Physical Laboratory of the University of Toronto was completed towards the end of 1922. In the preliminary operation of the plant, special facilities in the way of power were provided by the Hydro-Electric Commission of Ontario and by the Hydro-Electric Commission of Toronto.

[1] Trans. of the Chem. Soc. vol. 117, p. 923, 1920.

Helium was liquefied with the equipment for the first time on January 10 of this year, and the Cryogenic Division of the Physical Laboratory was formally opened on January 24, when demonstrations were given of the production of liquid air, liquid hydrogen, and liquid helium. Series of experiments were also shown illustrating the uses of these liquefied gases.

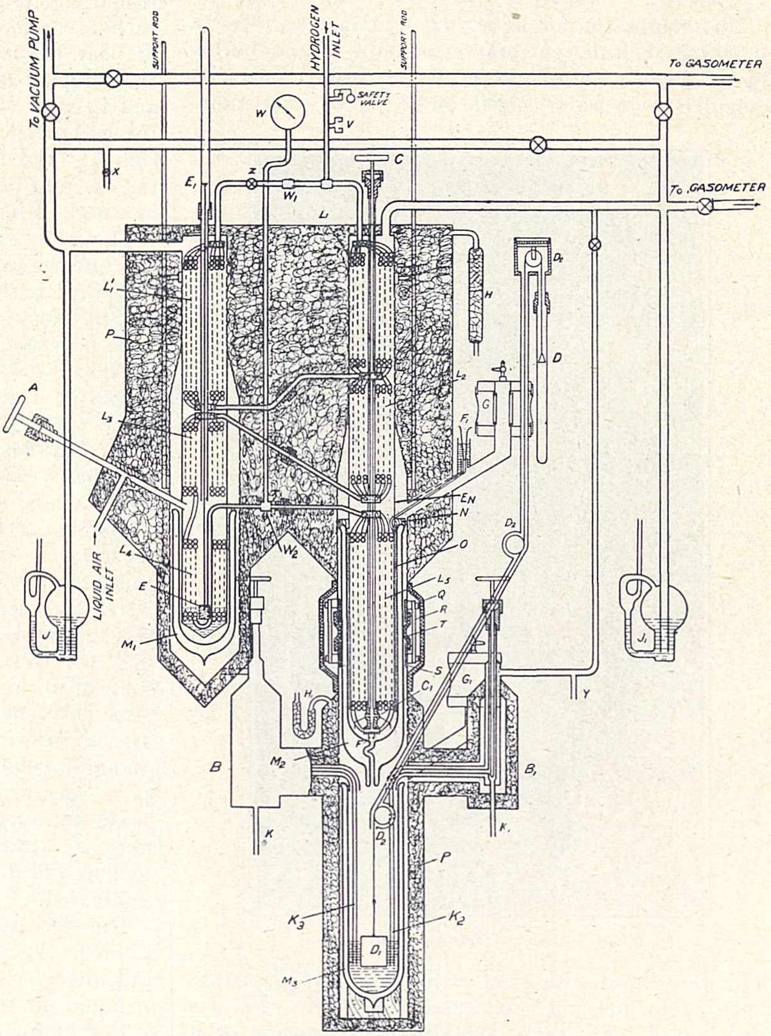

FIG. 1.—Hydrogen liquefier.

LIQUID AIR APPARATUS.

The apparatus constructed for the liquefaction of air consisted of a 40-kilowatt alternating current motor, a Norwalk compressor of the three-stage type, a water cooler, carbon dioxide purifying towers, and one of L'Air Liquide's machines having a capacity of producing 20 cubic metres of oxygen per hour. This machine was provided with valves which enabled one to isolate the rectification column from the oxygen heat exchanger, permitting the operation of the apparatus as a machine for liquefying air or as one for producing gaseous oxygen. The column was also provided with modifications for the extraction of the rare gases from the atmosphere. In operating this apparatus the air was compressed to 40 atmospheres, and in a series of tests it was found that about 300 kilograms of liquid air could be made per day. With such a supply of liquid air available, ample provision was made, it will be seen, for meeting the needs in regard to liquid air of all departments of the University.

Liquid Hydrogen Apparatus.

The equipment for liquefying hydrogen included a four-stage belt-driven compressor built by the Burckhardt Engineering Works of Basle, Switzerland. Its cylinders were water-cooled, had a forced lubrication,

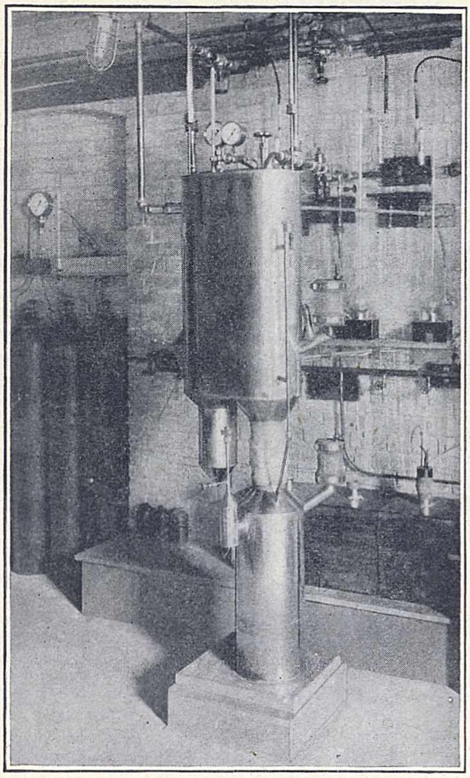

Fig. 2.—Hydrogen liquefier (as installed).

and were fitted with steel piston rings. The pistons were all in line and constituted one shaft. The gas was cooled after each compression by means of a number of heat exchangers immersed in a tank of running water. The compressor was constructed so as to prevent any loss of gas, and with this end in view, the piston rods were provided with special stuffing boxes in which the packing was sealed with oil contained in specially designed holders.

The space behind each piston as well as the safety valves was directly connected with a gasometer and through the latter to the intake of the compressor. The compressor had a capacity of 60 cubic metres of free gas per hour and required a motor of 30 kilowatts to operate it when delivering at 200 atmospheres pressure. Twenty litres of water per minute were disposed of by the heat exchangers.

The hydrogen liquefier is shown schematically in Fig. 1 and as it was installed in the laboratory by Fig. 2. The regenerator coils indicated were similar to those used in the well-known Hampson apparatus for liquefying air. In operating the liquefier, hydrogen specially purified was compressed to 150-200 atmospheres and cooled to $-205°$ C. by means of liquid air boiling under reduced pressure.

The compressed hydrogen passed successively through the coils L_1, L_1', L_2, L_3, L_4, and L_5. The coils L_1 and L_1' were arranged in parallel and the valve Z served to regulate the proportion of gas that went through each of them. This ensured the proper interchange of heat between the oncoming compressed gas and the outgoing low-pressure vapours. The coils L_1, L_2, and L_5 were cooled by gaseous hydrogen returning to the gasometer from the expansion nozzle C_1, and the coils L_1' and L_3 by the evaporated air drawn off by the vacuum pump. The coil L_4 was partly immersed in a bath of liquid air held in the flask M_1.

The valve A served to admit more liquid air from the reserve supply whenever the indicator E_1 of the cork float E showed that it was required. To add to the efficiency of the liquefier, the expansion coil L_5 was provided with a close-fitting German silver envelope which when properly wrapped with flannel permitted a good junction to be effected between the inner wall of the silvered vacuum flask M_2 and the coil. This ensured that the expanded gas passed over the closely wound tubes of the coil and so brought about a good exchange of heat.

The liquid hydrogen as it formed passed through the opening in the bottom of the flask M_2 and was collected in the silvered flask M_3. The float indicator D, D_1, D_2, served to show the level of the liquid in this collecting flask. The weight D was connected with the thin German-silver float D_1 by means of a silk thread running over three pulleys D_2 provided with jewel mountings. The valves B and B_1 were used for drawing off the liquid. These were arranged so that they could be pre-cooled by cold gaseous hydrogen as it was returned to the gasometer. The stuffing boxes and screw thread of the valves B, B_1, C and A were so arranged that they were not exposed to cooling and in this way the danger of a freeze-up was eliminated.

The insulation of the apparatus was specially studied. Vacuum flasks were used where possible, and wherever parts were cooled below the temperature of liquid air they were surrounded by an atmosphere of dry hydrogen or by a partial vacuum in order to avoid unnecessary condensation. All parts were constructed of German silver where it was an advantage to do so on account of its low thermal conductivity. The entire apparatus was packed in natural wool and enclosed in a thin brass case that was sealed except for the drying tubes H and H_1. These tubes served to equalise the internal and external pressures on the case and at the same time prevented water vapour from entering and condensing inside. Fig. 1 shows plainly the arrangement for supporting the apparatus together with the scheme of the pipe connexions. Mercury traps J and J_1 served to protect the apparatus at all times from any sudden but moderate excess of pressure, while the large rubber safety valves G and G_1 served to accommodate any sudden but violent increase of pressure such as might arise from the breaking of the flask M_3.

In operating with the hydrogen liquefier it was found necessary to remove all gaseous impurities from the gas. The commercial hydrogen used was made electrolytically and was found to contain as much as 1·5 per cent. of oxygen and 0·1-0·3 per cent. of nitrogen. To purify this gas it was passed through a high pressure bomb filled with palladiumised asbestos. This bomb was heated electrically to about 400° C., and at this temperature the palladium acted as a strong and robust catalyser. The water produced by the union of hydrogen with the oxygen present was taken up with caustic potash. The hydrogen obtained after this preliminary purification was again purified by passing it through a specially constructed apparatus provided with coils cooled with liquid hydrogen, but to make the liquid hydrogen for carrying out this purification it was necessary to operate the hydrogen liquefier with the hydrogen subjected to the preliminary purification only. A few litres only could be made in a run before stoppage occurred, and this was used to effect the final purification of a certain quantity of the gas.

By repeated operations of this character a supply of about 100 cubic metres of highly purified hydrogen was gradually accumulated, and with it long runs of the liquefier were made without any stoppage occurring. To conserve this original supply of pure hydrogen care had to be taken during a run to store up all gas from the vaporised hydrogen and to use residual supplies of liquid hydrogen to purify additional quantities of the gas so as to make up losses.

In liquefying hydrogen as well as helium, it was necessary in order to avoid losses so far as possible to operate in a closed cycle that included a gasometer, the compressor and the liquefier. In a number of actual runs with the apparatus described above, no difficulty was experienced in making from 10 to 15 litres of liquid hydrogen an hour, and in one particular run as much as 50 litres of liquid hydrogen was accumulated.

LIQUID HELIUM APPARATUS.

The helium used in the experiments was obtained from the natural gas of the Bow Island district near Calgary, Alberta, in the year 1919–20, and had been kept since then safely stored in steel cylinders at about 150 atmospheres pressure. An analysis by means of absorption with cocoanut charcoal showed the gas in different cylinders to be about 90-95 per cent. helium. The chief impurity was nitrogen, with a varying percentage of methane and other gases. Tests made by chemical absorption and explosion methods gave no indication of hydrogen being present.

The preliminary purification of the helium was effected by cooling it at a pressure of 150 atmospheres to −205° C. by means of liquid air boiling under reduced pressure. Under these conditions a large percentage of the impurity was condensed and drawn off. This partially purified helium was passed at high pressure first through a bomb filled with copper oxide and palladiumised asbestos maintained at a temperature of 400° C., and then through heavy copper tubes filled

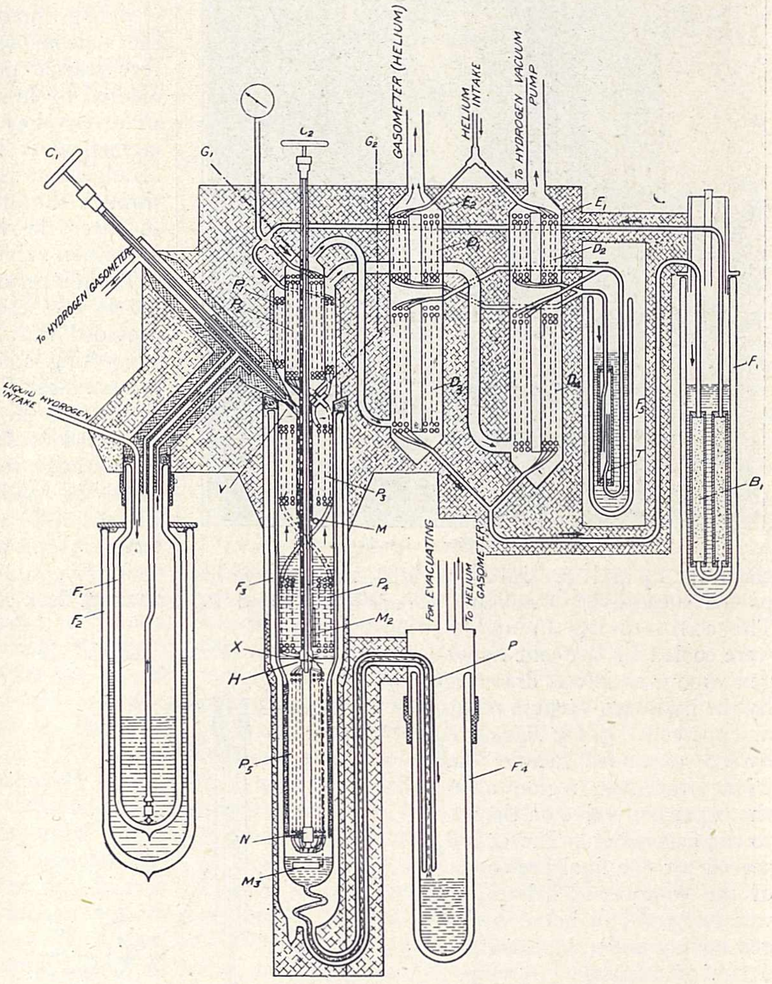

FIG. 3.—Helium liquefier.

with cocoanut charcoal and immersed in liquid air. This cycle of purification proved to be satisfactory, for during the liquefaction process there was no evidence at any time of any blocking of the expansion valve of the liquefier or of the very small capillary tubes that made up the expansion coil.

In the design and construction of the helium liquefier, special attention was given to problems connected with the heat capacity and heat insulation of the various parts of the apparatus. The liquefier is shown diagrammatically in Fig. 3 and the manner in which it was installed in the laboratory is shown in Fig. 4.

In the operation of the liquefier the manner in which the helium entered the apparatus is shown in the diagram. It passed successively through the coils D_1, D_2 and D_3, D_4 arranged in parallel. It then entered

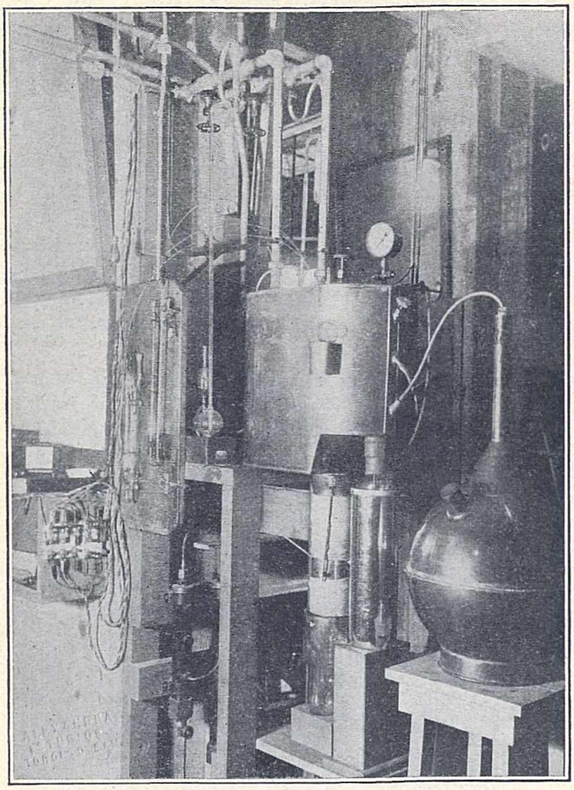

Fig. 4.—Helium liquefier (as installed).

the coils P_1 and P_2 also in parallel, and afterwards passed successively through the coils P_3, P_4 and P_5. The coils D_2, D_4, P_1 and P_3 were cooled by the cold hydrogen vapour as it was drawn off by the hydrogen vacuum pump, and the coils D_1, D_3, P_2 and P_3 by the expanded helium that issued from the region about the expansion valve on the way to the gasometer. The coil P_4 served for the final pre-cooling of the compressed helium and was immersed in liquid hydrogen boiling under a pressure of 6 cm. of mercury. A trap T was provided, by means of which the gas was freed from the last traces of oil or water vapour from the compressor. The tubes B_1 were made of copper and were filled with cocoanut charcoal. They were cooled with liquid air during the liquefaction process with a view of absorbing any gaseous contamination introduced during the operation of the cycle. The level of the liquid hydrogen in the refrigerator surrounding the coil P_4 was determined by means of copper-constantan thermo-couples, and alternatively by helium gas thermometers with reservoirs at M and M_2, that were connected with a mercury manometer by fine steel tubing G_2.

The liquid hydrogen from large vacuum-surrounded metal containers was first transferred to the unsilvered flask F_1, that was protected by an outer silvered flask F_2 containing liquid air. This flask F_2 was provided with two unsilvered vertical observation strips, one on either side, so that the level of the liquid hydrogen in F_1 could be seen directly. The valve C_1 controlled the intake of the liquid hydrogen from F_1 to the refrigerator, and the valve C_2 with its corresponding spindle controlled the expansion nozzle at the bottom of the coil P_5. The efficiency of the regeneration properties of the expansion coil P_5 was assured by fitting closely over it a very thin german-silver envelope soldered at X to the bottom of the german-silver liquid hydrogen container. With this arrangement the expanded helium was forced to go through the interstices of the expansion coil in order to enter the holes H in the tube surrounding the expansion valve spindle.

The temperature of the region beneath the expansion nozzle was determined with a helium gas thermometer provided with a german-silver reservoir at M_3 and a connecting steel capillary tube G_1. The protecting vacuum flask F_3 was provided with a specially designed siphon tube P. This tube was double-walled and was protected by silvering and by an intervening vacuum in the same manner as a Dewar flask. The flask F_4 could be made either totally silvered or partially silvered with a plain portion at the bottom. In the latter case it was protected by a plain vacuum flask containing liquid hydrogen, and this in turn by a plain vacuum flask containing liquid air.

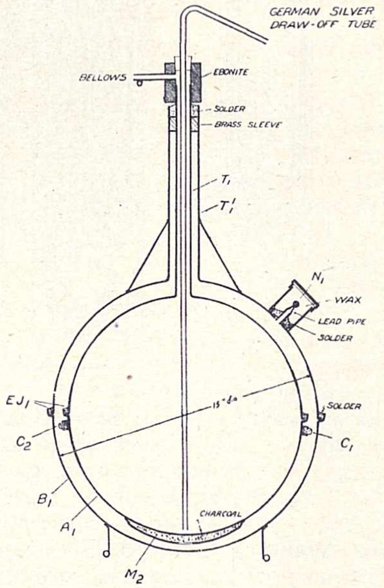

FIG. 5.—Metal container for liquid air.

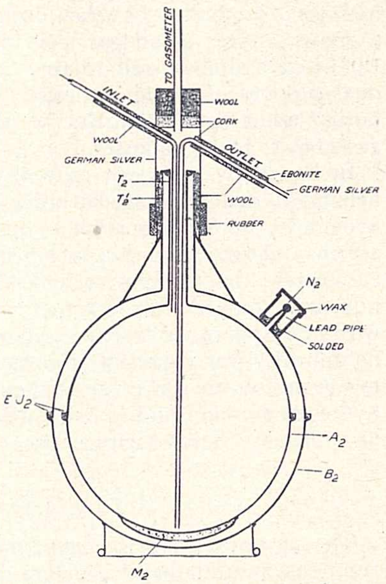

FIG. 6.—Metal container for liquid hydrogen.

These figures illustrate the types of metallic vacuum Dewar Flasks found useful in handling large quantities of liquid air and liquid hydrogen. They were made of polished spun copper. In assembling them, extreme precautions, it was found, had to be taken to remove not only the air but also all water vapour from the space between the spherical surfaces. A container of 25 litres capacity when well constructed did not lose so much as a kilogram of liquid air per day.

In constructing the hydrogen and helium liquefiers great care was taken to see that all the complicated tubing was free from holes and much time was consumed in the work of eliminating leaks. The whole apparatus was, however, completed towards the end of 1922 and, as stated, was used early in January of this year for the production of liquid helium. The helium was compressed with an enclosed Whitehead torpedo compressor, and the liquefier was found to give the best results when run at a pressure of only 40 atmospheres.

Before attempting to make liquid helium all parts of the liquefier were cooled as low as possible with liquid air, the piping being cooled by circulating through it helium that had been previously cooled to liquid air temperature. When this precaution was taken, it was found that liquid helium could readily be made with a moderate amount of liquid hydrogen supplied to the refrigerator surrounding the coil P_4. In our experiments less than 10 litres of liquid hydrogen sufficed to produce more than a litre of liquid helium.

I wish to take this opportunity of acknowledging my indebtedness to Prof. Kamerlingh Onnes of Leyden, the pioneer and outstanding authority in research at liquid helium temperatures. He not only assisted me very materially through correspondence and conversation, but also furnished me with drawings of the installation at Leyden.

It is hoped that with the cryogenic equipment now available at the University of Toronto, a series of low-temperature researches will be organised shortly for workers who for any reason may not find it convenient to go to Leyden to carry out investigations.

Rickets in Vienna.

A NUMBER of summary publications have made readily available the rapid advance in our knowledge of rickets in the last few years since Mellanby in 1918 brought forward serious evidence implicating a deficiency of fat-soluble vitamin A, and Huldschnisky in 1919 showed that the bone-lesions in children could be cured by ultra-violet light, and McCollum and his co-workers in 1921 demonstrated that the disease could be conveniently produced in rats by defective diets. Last year the Medical Research Council published the survey by Prof. Korenchevsky [1] of the experimental aspects and Dr. J. L. Dick [2] brought out a useful book on the human disease and its history. More recently an admirable survey of the whole question by Prof. E. A. Park [3] has appeared, and there has now been added a full account of the results of the expedition under Dr. Harriette Chick,[4] sent in 1919 to Vienna by the Lister Institute and the Medical Research Council, to study deficiency diseases under the conditions of almost experimental accuracy and precision afforded by the generous hospitality of Prof. v. Pirquet's Kinderklinik.

The report shows, beyond any reasonable doubt, that the incidence of rickets may be determined by diet, and that vitamin A plays an important part; that it may be prevented and cured by cod-liver oil; that it may be cured by sunshine or the rays from a mercury-vapour lamp, and that a diet which in summer is adequate for young infants may, in winter gloom, permit its development. From the practical point of view, the facts provide most of what the sanitarian needs: a proper supply of cod-liver oil, or its equivalent in vitamin A, and of sunshine, or its equivalent in ultra-violet light, will prevent rickets, and a deficiency of one may be made good by a larger supply of the other. What is at present unknown is how much vitamin A in the more customary forms of milk and green vegetables is wanted to give the same result as teaspoonfuls of the far more potent cod-liver oil. But there is no longer any excuse for there being two schools of thought disputing for a hygienic and a dietetic ætiology respectively: as usually happens in such controversies, it turns out that both parties are right.

In the larger matter of the circumstances which condition the proper and regular growth of bone the results are of great interest. Granting an adequate supply of the necessary materials—and of these calcium and phosphorus are the most obvious, and their importance has already been examined by direct experiment—vitamin A is necessary: with enough of this, rats grow satisfactorily in the dark (Goldblatt and Soames, *Biochemical Journal*, vol. xvii., 1923, p. 294). Ultra-violet light of about 300 $\mu\mu$ has much the same effect, and it was at first supposed, rather naturally, that it operated by causing a photo-synthesis of vitamin A. But rats on a diet grossly deficient in vitamin will grow normally under the influence of ultra-violet light only for a time: in the end, if no vitamin A is provided in the food, growth ceases, and the animals go downhill. Evidently light enables the animal to make the most economical use of such store of vitamin as it may have in its body or of any small amounts it may receive in its food: light can only partly replace vitamin, and if there is abundance of vitamin, light has no favourable influence on growth. In the same way vitamin makes a short supply of calcium or phosphorus go further, so that, while any of the three may be a limiting factor, up to a certain point of deficiency it is the sum (or product) of calcium phosphate and vitamin which is the effective determinant. Light *per se* is not a limiting factor, but may become the determinant under conditions of defect in the others.

Obvious as is the effect of ultra-violet light on the naked human skin, it is a little difficult to believe that it can act directly on the general body surface of hairy animals such as rats: "man is naked," as Richard Owen remarks, "and is the only terrestrial mammal in that predicament." It is, therefore, satisfactory to find it shown that air irradiated by the mercury vapour lamp is effective in promoting growth in rats, as Kestner showed it was in hastening the regeneration of blood lost by hæmorrhage: such air, in the absence of ultra-violet light itself, will also cure rickets in children. It does not seem to be known as yet whether radiation of the body surface with exclusion of radiated air

[1] Medical Research Council Special Report Series, No. 71. The Aetiology and Pathology of Rickets from an experimental point of view. Pp. 172+18 plates. (London: H.M. Stationery Office, 1922.) 4s. net.

[2] London: W. Heinemann.

[3] *Physiological Review*, vol. iii., 1923, p. 106.

[4] Medical Research Council Special Report Series, No. 77. Studies of Rickets in Vienna 1919–22 (Report to the Accessory Food Factors Committee appointed jointly by the Medical Research Council and the Lister Institute). Pp. 203+14 plates. (London: H.M. Stationery Office, 1923.) 7s. 6d. net.

from the lungs has any influence on bone-growth, nor on what constituent of the radiated air the effect depends.

It is possible that the mechanism in man is not quite the same as in hairy animals, and that direct irritation of the skin by sunshine—to which some clinical observers attach considerable importance—does much the same as irritation of the bronchial mucous membrane, which is embryologically the same as skin, by ionised air or traces of ozone or nitric oxide. If this is so, irritation of the skin by means other than ultra-violet light should have the same effect—which is perhaps the explanation of Dr. Mayo's observation on rickets in 1674 that "scabies or itching contributes much to its cure." Little is known about what has been called the "internal secretion" of the skin beyond the fact that irritation may lead to changes in other parts of the body. Thus a blistering agent applied locally may considerably increase the susceptibility of the whole skin to the same substance.

Current Topics and Events.

In an article which appeared in Nature of July 21, p. 101, the view was expressed that the constitution of the committee of the recently formed British Empire Cancer Campaign was not such as would command the respect of *bona fide* workers on the cancer problem. While our article was in type, a meeting of the Grand Council of the British Empire Cancer Campaign was held, and contrary to the original intention, and no doubt as a result of informed public opinion, it was decided to appoint a scientific advisory committee of ten members. It was urged, however, that an attempt should still be made to preserve the balance between scientific and clinical workers. On the following day the annual meeting of the Imperial Cancer Research Fund was held under the presidency of the Duke of Bedford, who expressed himself as in entire agreement with the attitude which had been adopted by the executive committee of the Fund in resisting the danger of being drawn into the British Empire Cancer maelstrom. In an admirable review of the work of the campaign he directed attention to the crass ignorance which prevails with respect to the work which has been done by the Fund, and he laid great stress on the necessity for the British Empire Cancer Campaign to be in the hands of those acquainted with work already done, as this is the only means of avoiding useless repetition and preventing the waste of funds obtained from a generous and sympathetic public.

Congratulations are due this week to the Rev. Dr. T. G. Bonney, who celebrated his ninetieth birthday on Friday, July 27, having been born at Rugeley, Staffordshire, in 1833. The son of a clergyman, Dr. Bonney was the eldest of ten children. Educated at Uppingham, he was sent to St. John's College, Cambridge, where he graduated twelfth wrangler, and soon after accepted a post as mathematical master at Westminster School. It has been said of him as regards his early education, that "mathematics had impressed upon his mind the real necessities which are demanded by a proof; classics had assisted him to cultivate a literary gift; and travel had taught him facts at first hand." Ordained a priest in 1858, in the following year he was elected to a fellowship at St. John's. In 1877 Dr. Bonney took up the professorship of geology in University College, London, a post he held until 1901. For four years secretary of the British Association, he was president of the Geological Society, 1884–86, and president of the British Association at the Sheffield meeting of 1910, giving an address on some aspects of the glacial history of Western Europe. In 1889 he was awarded the Wollaston gold medal of the Geological Society. In allotting the gift the then president remarked that in Dr. Bonney's hands the microscope had been a valuable adjunct to field-observation and had been chiefly applied to detect the secrets of those rocks which, possessing no organic remains to betray the tale of their origin, had hitherto baffled inquiry into their early history.

On June 16 the Polish Academy of Sciences and Letters at Cracow celebrated, in the presence of the President of the Polish Republic, the fiftieth anniversary of its foundation. The Academy originated in 1873, evolving from a scientific society which has existed in Cracow since the beginning of the nineteenth century. The first president of the Academy was Józef Majer, a man who rendered valuable service to the cause of science in Poland; he was succeeded by Count Stanislas Tarnowski, for many years professor of the history of Polish literature in the Jagellonian University; Prof. Casimir Mozawski, a philologist of European renown, is now president. The Academy is divided into three classes—devoted respectively to philology and linguistics, to historical and social science, and to mathematical, physical, and natural science. In conformity with the statutes, the Academy consists of 60 active Polish members, 36 foreign and 96 corresponding members. The publications of the Academy since 1873 are numerous; they include 206 volumes of the Transactions of the Classes, 50 volumes of the Proceedings (the Cracow *Bulletin International* is well known to scientific men all over the world), 10 volumes of a beautiful publication intended to promote the cultivation of the history of art in Poland, 146 volumes of transactions of various committees appointed to elucidate problems in the history of Polish language, literature, and civilisation, 90 volumes of publications on Polish political and economical history, 57 volumes of the Transactions of a special committee investigating the physiography of Poland (meteorology, geophysics, mineralogy, and geology, systematic botany and zoology), 36 volumes of the Transactions of the Anthropological Committee, 10 volumes of the "Polish Encyclopædia" (in course of publication), and more than 300 volumes of various other works separately published. The Academy possesses a fine library (with many valuable MSS.), remarkably rich physiographical and anthropological collections, a permanent scientific station at Paris (4 Quai d'Orleans), and a quasi-permanent station (chiefly for historical investigation) at Rome.

DR. A. E. H. TUTTON is to be congratulated on the completion of a laborious piece of work which he set himself in 1890. This was the investigation of the isomorphous relations existing between the sulphates and selenates of the alkali metals and ammonium and the double salts of these with certain divalent metals. It is noteworthy that this work has been performed in his spare time, and for the last twelve years in Devonshire. In his presidential address to the Devonshire Association at Salcombe on July 10, he gave a general review of the results attained and of their bearing on the structure of crystals and of atoms. In all, seventy-five salts have been worked out in the greatest possible detail and their crystallographic and other constants determined with the highest degree of accuracy, for which purpose several elaborate instruments were specially designed. In eighteen groups, in which potassium, rubidium, and cæsium are the replacing elements, it is repeatedly and conclusively proved that the constants vary with the atomic weights of these elements, and consequently also with their atomic number and atomic diameters. The dimensions deduced for the structural units of these crystals have since been amply confirmed by the X-ray analysis of crystal-structure. But the more direct and very carefully made observations will be of permanent value for testing theories of the future.

AT a meeting of the Board of Directors of the Manchester Chamber of Commerce held on July 16, the following resolutions were passed unanimously: That, whereas the word "gallon" is at present capable of different interpretations (due to the difference of about 20 per cent. between the Imperial and the American gallon), and whereas the alternative use of the litre is already sanctioned by law throughout the commercial world, it is desirable that all traders—especially those concerned in overseas trade—should promote uniformity of trading practice by employing the litre as the sole unit of capacity. (*N.B.* If those engaged in any special trade desire to retain the word gallon it should be in the form of a "new gallon" equal to 4 litres, which would approximately represent the average value of the present conflicting gallons.) That, whereas the word "ton" is at present capable of different interpretations according to whether the "long," "short," or "metric" ton is intended, and whereas the use of cwts., quarters, stones, and other local weights involves further confusion and loss of commercial efficiency, it is desirable that all traders—especially those concerned in overseas trade—should express the weights of goods in pounds only, and convert such pounds when desirable into equivalent weights in kilograms.

OWING to the work of redecorating the rooms of the Chemical Society, the library will be closed during the entire month of August, and in accordance with the usual practice will close at 5 P.M. daily on September 1-17.

THE following have been elected honorary members of the Society of Chemical Industry: Prof. C. F. Chandler, United States; Prince Ginori Conti, president of the Italian Chemical Society; M. Paul Kestner, president of the French Society of Chemical Industry; Prof. Joji Sakurai, Japan; and Sir Dorabji J. Tata, India.

THE annual autumn meeting of the Institute of Metals will be held in Manchester, on September 10-13. The meeting will open with the second annual autumn lecture, to be delivered by Sir Henry Fowler, on "The Use of Non-ferrous Metals in Engineering." Papers will be read and discussed on the mornings of September 11 and 12, and visits to works and places of interest in the neighbourhood have been arranged.

APPLICATIONS for Yarrow Research Professorships will be received by the Secretaries of the Royal Society until October 1 next, as the president and council of the society will in the autumn consider the appointment of one, or possibly more, professors who will be expected to devote their whole time to research in the mathematical, physical, chemical, or engineering sciences. Further particulars are obtainable from the Assistant Secretary of the Royal Society, Burlington House, Piccadilly, W.1.

AT the annual general meeting of the Royal Veterinary College held on July 17 the Duke of Connaught, president of the College, announced that, in conformity with the recommendation recently made by the advisory committee on Research in Animal Diseases, the Development Commission, through the Ministry of Agriculture, has made a grant of 25,000*l.* for the erection of a new research institute in connexion with the College. It is hoped that the new premises will be ready for occupation in less than a year.

AT the recent meeting of the trustees of the Beit Memorial Fellowships for Medical Research, the honorary secretary, Sir James Fowler, presented a review of the work of the trust for the period 1910–1923. Since the foundation of the trust in 1909, seventy-nine fellowships have been awarded. Originally the annual value of the fellowships was 250*l.*; this was increased to 300*l.* in 1919 and to 400*l.* in 1920. In 1922 they were reclassified as junior, fourth-year, and senior, with the values, 350*l.*, 400*l.* and 600*l.* respectively. Of the first fifty fellows elected, two have been made fellows of the Royal Society, eight have secured professorships, four have become directors of research institutes, and most of the remainder are holding responsible appointments.

THE Ramsay Memorial Fellowship Trustees have made the following elections to fellowships and renewals of fellowships for the Session 1923–24, the place of research where stated being given after the name of the fellow elected : *British Fellowships* (300*l.*): Dr. S. Coffey, at University College, London ; Dr. A. F. Titley ; and Dr. R. W. Lunt, at University College, London. *Glasgow Fellowships* (300*l.*) : Mr. T. S. Stevens and Mr. J. A. Mair, both at the University of Glasgow. *Norwegian Fellowship* (5400 kroner) : Mr. G. Weidemann, at the Biological Laboratory, University of Cambridge. *French Fellowship* (100*l.* plus 14,000 francs) : Dr. H. Weiss, at the Royal Institution (Davy-Faraday Laboratory). *Netherlands Fellowship* (300*l.*) : Mr. J. Kalff. *Danish Fellowship* (300*l.*) : Mr. K. Højendahl, at the University of Liverpool. Since the institution of the Ramsay Memorial Fellowship Trust in 1919 twenty-one fellowships, not including those announced above, have been awarded.

THE thirty-fourth congress of the Royal Sanitary Institute will be held at Hull on July 30-August 4 under the presidency of the Right Hon. T. R. Ferens. The proceedings will be divided among four sections dealing with sanitary science, engineering, and architecture, maternity and child welfare, and personal and domestic hygiene respectively. In addition to the sectional meetings a number of conferences of representatives of sanitary authorities, medical officers of health and similar workers have been arranged. Sir Alexander Houston will lecture to the Congress on " A Pure Water Supply," and among the subjects to be discussed at the various meetings are the prevention of tuberculosis and cancer, the curative value of ultra-violet rays, the nutritive value of milk, heliotherapy, the smoke evil, and food-poisoning. Several Government departments and also foreign and Dominion Governments are sending delegates. Visits will be paid to local institutions, water-works, and factories, and a Health Exhibition showing apparatus and appliances relating to health and domestic use will be open throughout the meeting.

THE 104th annual meeting of the Swiss Society for Natural Sciences will be held on August 30–September 2 at Zermatt. This will be the fifth occasion when the Society has met in the Canton of Valais. The work of the meeting will be divided into fifteen sections as follows : (1) Mathematics, (2) physics, (3) geophysics, meteorology, and astronomy, (4) chemistry, (5) geology, mineralogy, and petrography, (6) botany, (7) zoology, (8) entomology, (9) palæontology, (10) anthropology and ethnology, (11) medical sciences, (12) history of medicine and the natural sciences, (13) veterinary medicine, (14) pharmacy, and (15) engineering science. In addition to the sectional gatherings, there will be general discussions which will be addressed by distinguished men of science. Among the topics thus dealt with will be : Phylloxera in Valais, by Dr. H. Faés, director of the Federal Viticultural Station, Lausanne ; earthquakes in Switzerland, by Dr. A. de Quervain, of the University of Zurich ; and the geology of the neighbourhood of Zermatt, by Prof. E. Argand, professor of geology, palæontology, and petrography in the University of Neuchâtel. The following officers have been appointed for the meeting : *President*, Rev. C. M. Besse ; *Vice-President*, Dr. J. Amann ; *Treasurer*, M. E. de Riedmatten, and *Secretary* M. A. de Werra, of Sion, Valais.

THE National Research Council of the United States has issued as a Bulletin an account of the State Research agencies of Illinois other than the University, prepared by Prof. L. D. White of the University of Chicago. These agencies spent 40,000*l.* on research during the fiscal year 1921-22, employing 230 scientifically trained workers. The smallness of the grant is due largely to the claims for research being subject to review by non-professional administrators who have no very definite understanding of the aims of research. The salaries paid to the research workers are small, and the best men are attracted by the posts open to them in industry. While managing officers receive from 500*l.*-1000*l.* per annum, engineers, geologists, naturalists, and bacteriologists from 300*l.*-700*l.*, and medical officers and psychologists 350*l.*-570*l.*, chemists receive only 250*l.*-450*l.* per annum. The report recommends that research officers should be relieved of routine work, that the University should be recognised as the central research agency, and that the salary scale should be equal to that maintained in the University for persons of similar professional attainments.

THE Årsbok for 1922, Part II., of the Swedish Meteorological Service gives full details, accompanied by maps, of the precipitation in Sweden. For each month of the year are given a summary of the fall for each province, with a comparison of the mean average fall, and the details of several hundred stations throughout the country. For each station are given the total fall in the year, the total for the wettest day, and the number of days with precipitation more than certain amounts. There are maps of the monthly and annual distributions of rainfall, and a large map showing the distribution of the recording stations.

BULLETIN No. 13 of the Madras Fisheries Department (1922) contains the Reports on Administration for the years 1919–20. The publication is, however, a notable one in that it also contains a long report (pp. 35 to 266) by Sir Frederick Nicholson on methods of fish canning, preparation of oils, guano, etc., with special reference to local methods. There is also an interesting account of the " solar oven," a contrivance for entrapping the heat of the sun in a confined atmosphere. With an outside temperature of 140° F. that of the inside of the oven reached 325° F.

IN the July issue of the *Antiquaries Journal*, Sir Hercules Read publishes his presidential address delivered on St. George's Day. It is devoted to the question of collaboration in archæological research with foreign nations, in particular with France and the United States. Special attention is paid to the question of an agreement with the Afghan Government which granted to the French through M. Foucher a perpetual monopoly of archæological investigation in Afghanistan. This was a serious invasion of the rights of India to share in the excavation of the important Buddhist sites beyond its north-western frontier. It is satisfactory to learn that the matter has now been amicably arranged. The French Government has also expressed readiness to welcome the collaboration of British investigators, and the existence of the concession will not affect their participation.

A LIST of the new books and new editions added to Lewis's Medical and Scientific Circulating Library during June has just been issued by Messrs. H. K. Lewis and Co., Ltd., 136 Gower Street, W.C. 1. It is sent free upon request.

MESSRS. J. AND A. CHURCHILL announce the early publication of the translation of vol. 2, pt. 2 of Molinari's "Organic Chemistry," completing this section of the work. The new part will deal with the esters, oils and fats, sugars and other carbohydrates, cyclic compounds, dyestuffs, textile fibres, proteins, etc.

UPWARDS of 1600 works in botany, zoology and general natural history, many of which are rare, are included in the latest catalogue (New Series, No. 8) of Messrs. Wheldon and Wesley, Ltd., 2 Arthur Street, W.C.2. They originally belonged respectively to Prof. G. A. Boulger, Mr. F. N. Campbell, Sir F. W. Moore and Sir Edmund Giles Loder, Bart. The list is worthy of perusal.

AMONG the announcements of Messrs. Ernest Benn, Ltd., are "The Art of the Chinese Potter," by A. L. Hetherington and R. L. Hobson, which will illustrate 192 choice examples of pottery dating from the Han Dynasty to the end of the Ming, in a series of coloured and half-tone plates; "The Art History of Ancient Peru," by Drs. W. Lehmann and H. Döring, being the first publication of the Research Department of the Ethnographical Museum, Berlin, and "Introduction to the Study of Chinese Painting," by A. Waley, which will be compiled almost entirely from native texts, few of which have been translated before.

Our Astronomical Column.

D'ARREST'S COMET.—No news of the detection of this comet is yet to hand; this is not altogether surprising, as it has been noted faint at previous returns; and as it has not been seen for two revolutions, the positions given may be somewhat in error. The search is still possible in August; in fact, the maximum brightness is in the last week of August. The following is a continuation of Mr. F. R. Cripps's ephemeris (for midnight):

	R.A. h. m.	Decl.	log r.	log Δ.
July 28.	16 29·6	4° 39′ N.		
Aug. 1.	16 32·8	2 45	0·160	9·837
5.	16 37·1	0 46 N.		
9.	16 42·1	1 17 S.	0·151	9·837
13.	16 47·2	3 24		
17.	16 54·1	5 34	0·143	9·840
21.	17 1·5	7 46 S.		

r, Δ are the distances from sun and earth in astronomical units.

The comet should be looked for about 20° west of south, as soon as the sky is dark.

THE CEPHEID VARIABLES AND THE DISTANCE OF THE CLUSTERS.—These variables were largely used by Prof. Shapley in his deduction of the distances of the globular clusters. In the last two years both Prof. Curtis and the late Prof. Kapteyn have challenged these distances; they suggested values about one-seventh of Shapley's. Kapteyn's result was based on all the available proper motions of the Cepheids; he concluded that these were larger than would be expected on Shapley's formula of their distance. Mr. R. E. Wilson, of Dudley Observatory, Albany, returns to this question in *Astron. Journ.* No. 821; he uses all Kapteyn's material, together with a considerable amount of new matter, so that his list contains eighty-four stars. He divides them, as others have done, into the short-period cluster type, and those with periods exceeding two days. Mr. Wilson has also collected observations of radial velocity for thirty of these stars, six being of type I. His conclusion is that these short-period variables are rapid movers in space, the indicated velocity being of the order of 100 km./sec. He therefore considers that Kapteyn's distances for these stars, which were based on a much lower assumption of linear speed, are too small. The stars of longer period are presumably more massive, and their peculiar speed is found to be 12 km./sec. Wilson's estimate of the cluster distances is of the same order as Shapley's, but he suggests a reduction of the latter by an amount not exceeding 40 per cent.

Mr. Wilson also uses his results to test Kapteyn's suggestion that Boss's proper motions in declination need systematic correction by the formula $+0{\cdot}013''$ cosine decl. The material is too scanty to give a conclusion, but it suggests that a correction of half the size indicated by Kapteyn is needed.

PHOTOGRAPHY OF METEORS.—The great difficulty in "catching" a meteor on a photographic plate is referred to by Dr. Harlow Shapley in a brief report on a photographic survey for bright meteors (Harvard College Observ. Bull., No. 788). Harvard College possesses a series of plates extending over an interval of twenty-three years. Each plate covers more than twelve hundred square degrees, and the average length of exposure is sixty-nine minutes. These plates show stars to the eleventh photographic magnitude or fainter, and were made with a one-inch Cooke lens of thirteen inches focal length. The most striking result of this systematic examination of 641 direct photographs is the infrequency of meteor trails. Four sets of regions and time intervals were so chosen that each included the radiant point and the date of a well-recognised meteor shown, and the total exposure time for all these plates amounted to 44,266 minutes. Thus, as is stated, the present survey is equivalent to a photographic search for bright meteors for 738 hours over a region with a diameter of nearly forty degrees, and yet only twelve meteors were recorded. The results are briefly summarised as follows:

	No. of Plates.	Total Exposure min.	Meteor Trails.
Perseids . . .	95	6,379	3
Orionids . . .	93	6,250	0
Leonids . . .	143	9,528	1
Andromedids .	310	22,154	8

ERRATUM.—Meteor of July 11, p. 110, last line. For "15° W. of south" read "15° E. of south."

Research Items.

THE SCOTTISH TABOO OF PORK.—In the memoirs of the Manchester Literary and Philosophical Society (vol. 661), Mr. Donald A. Mackenzie investigates the Scottish objection to the use of pork. He remarks that while the Celts, the medieval clergy, Angles, Saxons, Vikings, and Flemings settled in Scotland reared swine and ate their flesh, the prejudice against this meat was perpetuated by the descendants of the indigenous races, the common folk. The prejudice in the Hebrides has been acquired from them, and James VI. of Scotland and some contemporary lords likewise succumbed to the taboo. Mr. Mackenzie doubtfully traces the belief to Egypt, where Set, the slayer of Osiris, "was the prototype of the Satanic pig demon," and the cult of the pig was associated with that of the Great Mother.

PRIMITIVE STONE WEAPONS FROM UGANDA.—In the publication of the Geological Survey of Uganda (Occasional Paper No. 1) Mr. R. A. Smith of the British Museum and Mr. E. J. Wayland, director of the Geological Survey, Uganda, describes a collection of stone implements made in that province. A report on some of the implements, resembling the rostro-carinate type from below the Suffolk crag, has been already published by Mr. Reid Moir (NATURE, July 21, 1921, p. 649). As only a selection of those implements has come to Europe, Mr. Smith believes that "it would be premature to use these types as evidence of date, in reliance on parallel forms elsewhere; but the palæolithic character of thousands of flints from Egypt is now generally admitted, and the publication of a new series from Uganda may throw light on the Stone Age of Africa in general."

RUGBY AND HOCKEY IN ANCIENT GREECE.—In the April issue of *Discovery*, Mr. Stanley Casson directs attention to one of the most remarkable finds of Greek sculpture in the city wall of Atticus, near the so-called Theseium. These have been already published in the *Journal of Hellenic Studies* for 1922. In one of the reliefs, the players are grouped round an imaginary central line which divides the relief into two equal parts. The six players thus form two teams of three. The foremost on each side is moving at a moderate pace, the central figures at a faster pace, and the figures at the back of each team at a slow pace, almost a walk. To use modern Rugby terms, they might be called "forwards," "three-quarter-backs," and "full-backs." The team that appears to be advancing has possession of the ball, which is a small one, and is held in the hand of the "full-back." Mr. Casson goes on to show that four games of ball, one the Athenian form of Rugby, are described in the "Onomasticon" of Julius Pollux dedicated to the Emperor Commodus, about A.D. 177, which may be described as a "young man's guide to University life." The relief depicting the Athenian equivalent of hockey is of equal interest.

ANATOMY OF THE SHIELD-URCHINS.—Prof. Koehler of Lyons has taken the opportunity presented by his account of the Echinoidea in the Indian Museum (Calcutta, 1922) to study, so far as the state of the material permitted, the internal anatomy, particularly that of the gut, in the Clypeastroida or shield-urchins. He has discovered a composite gland, lying along the front part of the ventral coil of the intestine, and presumably pouring into it some digestive secretion. This intestinal gland was found in all those of the Clypeastroids examined that had the auricles for the attachment of the jaw-muscles separate, but not in those where the auricles were fused into inter-radial processes. The classification based on that skeletal feature thus receives confirmation; but the correlation is no doubt primarily physiological. The arrangement of the intestinal siphon (or by-pass) is also found by Prof. Koehler to vary according to the families already recognised. The relation of the internal calcareous pillars of the Clypeastroids to the soft parts is patent: it can be detected even in the fossils. Prof. Koehler has therefore little difficulty in showing the importance of this so-called "endoskeleton" for classification. The only difficulty that might arise, namely, the reluctance to break open a rare specimen, is, as his excellent photographs prove, easily overcome by radiography. This important memoir on recent sea-urchins will thus strengthen the student of their fossil relatives in his conviction that he is proceeding on safe lines when he bases his genealogies on minute differences of skeletal structure.

MYXOSPORIDIA PARASITIC UPON JAPANESE FLAT FISHES.—In the Journal of the College of Agriculture, Hokkaido Imperial University, Sapporo, Japan, T. Fujita shows that the flat fish of Hokkaido are more highly susceptible to the infection of myxosporidian parasites than the allied forms in the North Sea, the infecting ratio of the parasites being 94 per cent. in the species of the hosts, and 68 per cent. in 453 fishes examined. Observations were made on the gall bladder, this being the most favoured site of the parasites. The species of parasites found are of three genera and eleven species—three of Leptotheca and four of Ceratomyxa and of Myxidium. All are new species. Usually only one was found in a species of the host, though Myxidium was found existing with Ceratomyxa or Leptotheca; the two latter rarely associated together. Ceratomyxa gives the greatest infection and predominates on the east coast. The other genera named are found mostly on the west coast. There appears to be some relation between the occurrence of the parasites and the geographical position of the locality from where the fish are taken. There is an increase in frequency the farther south the fish are found. The author concludes that some parasites seem to prefer a certain depth as their proper abode, Leptotheca attacking mainly the fish in shallow seas while Ceratomyxa abounds mostly in deeper waters.

BARK CANKER OF APPLE TREES.—Part IV. of volume 8 of the Transactions of the British Mycological Society contains a paper of considerable economic interest by Grace G. Gilchrist upon bark canker disease of apple trees. This disease, due to the fungus *Myxosporium corticolum* Edgert., produces large longitudinal scars upon the branches. It has been described by American workers, who regard the damage it produces as negligible. Miss Gilchrist points out that the two outbreaks recorded for England both show severe damage produced as a result, the wood as well as the cortex of the trees being affected.

THE STRUCTURE OF THE PLANT CELL WALL.—The Journal of the Textile Institute, vol. 14, No. 4, April 1923, contains a long paper by H. J. Denham upon the structure of the cotton hair, which deals with the problem of the formation of the plant cell wall. Recent papers by Dr. W. L. Balls have suggested that the thickening of the wall follows by regular deposition of cellulose upon a plan predetermined by the structure of the primary wall which is deposited during the period of extension in length of the hair. Mr. Denham seems unable to agree with this view, as he finds that the striation patterns of the secondary layers may differ from each other and from that of the primary wall upon which they are deposited. This difference in point of view should promote the advance of our knowledge of the wall structure, and certainly both these workers have materially added to our technique in this difficult field. One may cite, for example, the photographic illustration in the present paper of the growth-rings first demonstrated by Dr. Balls and of other wall structures, such as pits and spirals. Mr. Denham illustrates and discusses at some length the various abnormalities in cell-wall structure met with by several workers, and shows that considerable importance may attach in this connexion to the development of the hairs crowded and compressed within the boll. Based partly upon the study of the staminal hair of Tradescantia, the very interesting suggestion is made that the spiral striation in the cell wall may follow from its deposition along the track of the spirally rotating cytoplasm. Such a spirally rotating band of cytoplasm will of necessity travel in two streams, lying side by side but moving in opposite directions, and the deposition of particles from such a moving band would be expected to vary from the centre of the band to the margin. Here the author finds a possible explanation of the double spiral line of weakness which he demonstrates in the wall of the hair and regards as the cause of the convolutions which are so important to the spinner.

THE DIAMOND-PIPES OF ARKANSAS.—The first diamonds from Arkansas were picked up near Murfreesboro in 1906, on the surface of a pipe of peridotite that had been correctly appreciated by J. C. Branner seventeen years before. Abundant small stones are now extracted from surface-diggings in the decomposed peridotite or peridotite-tuff that fills exploded vents, and the associated strata clearly show that the intrusions occurred at the opening of Upper Cretaceous times. The question as to whether the diamonds were generated in the ultrabasic magma, or whether they have been brought up from some mass through which the invader broke, cannot be regarded as settled; but the list of their associates, including garnet and diopside, seems to indicate the presence of eclogitic rocks in the depths. The occurrences have now been described by H. D. Miser and C. S. Ross in Bulletin 735-I of the U.S. Geological Survey (1923). The largest diamond so far recorded from Arkansas weighs 20·25 carats, which comes within the limits of what may be regarded as a large stone. The age of the pipes is of interest in connexion with what is now known as to the S. African examples.

THE CARBONIFEROUS FLORA OF GREAT BRITAIN.—Under the auspices of the Geological Survey, Dr. Robert Kidston is bringing together the results of his long and happily continuing work on British Carboniferous plants. It is proposed to issue some ten quarto parts as Volume II. of the palæontological memoirs of the Survey, including critical descriptions and illustrations of every known species in the flora. The first two of these parts are now ready (1923), price 15*s.* and 12*s.* 6*d.* respectively. There is nothing on the covers to indicate to the purchaser that he is not receiving the whole work on the "Fossil Plants of the Carboniferous Rocks of Great Britain" in the limits of one part, and the separate sheet issued with Part 2 would lead him to conclude that he was dealing with the second part of the second volume of the book. The final title-page will set this right for our librarians. So far, all the species retained in the "form genus" Sphenopteris have been dealt with; but it is suggested that some may in the future be removed from the ferns to the pteridosperms as their mode of fructification becomes known. The photographic plates, by the Zinc Collotype Co. of Edinburgh, are admirable in the lighting of the specimens. Dr. Kidston's broad outlook makes the memoir a noble contribution, not only to palæontology, but to stratigraphy. On the latter point we may note that the author adopts "Westphalian," but not "Viséan," "Tournaisian," or our own broad "Aronian," and that the "Millstone Grit" horizons become divided (p. 14) between a "Lanarkian" series in the Upper Carboniferous and the highest beds of the Limestone series in the Lower Carboniferous sub-system.

THE SALTS OF THE DEAD SEA AND RIVER JORDAN.—In the *Geographical Journal* for June Mr. W. Irwin has a paper on this subject. Analyses of samples of Dead Sea water show considerable variation according to the spot from which the sample is taken, but the total solids do not vary greatly. The outstanding change is a decrease of sodium salts and an increase of magnesium salts on passing from the north to the south, and to the deepest part of the centre of the lake. This alteration can be caused only by the sodium salts crystallising out on the bottom, leaving the more soluble magnesium salts in solution. Tests of Jordan water show a surprising salinity, averaging, at Jericho, 0·0364 gm. chlorine per 100 c.c. Further analyses in different stretches of the river gave interesting results. As near its source as the Waters of Merom it is highly impregnated with salts, chiefly chlorides of sodium and magnesium, and the composition of the water does not change as far as the Sea of Galilee. In the Sea of Galilee there is a slight increase in these chlorides and a decrease in calcium sulphate and silica, due no doubt to evaporation on one hand and precipitation on the other. By the time the river reaches Jericho there is an increase of salts, especially magnesium chloride. The result of these investigations is to suggest that the principal origin of the salt in the Dead Sea is from the Jordan, which brings it from Hermon and possibly Lebanon. Assuming the bulk of magnesium chloride to be provided by the Jordan, the present level of the Dead Sea must be rising at the rate of 1 ft. in 125 years, for the Jordan brings in 181 million pounds a year, and if the solution is already concentrated and none crystallises out, as appears to be the case, an annual additional depth of water estimated to be 1/125 ft. is required.

WEST INDIAN EARTHQUAKES.—Prof. S. Taber has recently published an interesting study of the seismic belt in the Greater Antilles (Bull. Seis. Soc. America, vol. 12, 1922, pp. 199-219). In this region, the major relief features are zones of normal faulting developed in late geological times, and still, as the occurrence of earthquakes shows, being developed. The two most persistent fault-zones are the Swan Island–Jamaica–South Haiti and the Cayman Islands–Sierra Maestra–North Haiti, which are roughly parallel for a distance of nearly 2000 km. and are only 100 to 150 km. apart. The narrow strip between these fault-zones is depressed in its western and central portions so as to form the Bartlett trough (3506 fathoms). With few exceptions, all strong Antillean earthquakes have originated along a few well-defined belts which coincide with the major fault-zones of the region. There is no evidence either of a continuous change in the seismicity of the region or of any well-defined periodic variation. When severe earthquakes have been separated by a short time-interval, their epicentres have been in the same fault-zone and only a short distance apart, thus indicating that the displacement was being extended along the strike of the faults. Most of the great earthquakes originating along the shores of the islands have been accompanied by sea-waves, each of which, so far as known, has been propagated with the trough in advance of the crest. The wave thus seems to indicate a sudden downward displacement of the ocean-bed. Disastrous earthquakes seldom recur in exactly the same place except after long intervals. Thus, those parts of the zones of active faulting near which severe earthquakes have not occurred in historic times are to be regarded as seismically the most dangerous.

VOLUMETRIC DETERMINATION OF RAINFALL.—A paper on this subject by Mr. C. S. Salter was read before the Inland Navigation section of the thirteenth International Congress of Navigation held recently in London, and is published as a pamphlet. The sources of error in rainfall records are three: design of rain-gauge, exposure of rain-gauge, and interpretation of records in terms of volume. Mr. Salter's paper deals with the last consideration. Owing to the fact that rainfall is extremely variable in its incidence in time and its distribution in space, the reading of an individual rain-gauge must be regarded as merely a sample. The total rainfall of an individual month in Britain may vary by 400 per cent. from the average value, and that of an individual year by 70 per cent. When the period of records is short no allowance for the variation of time is possible, but a correction can often be applied from adjacent long records. Generally speaking, in rainy districts, where thunderstorms and sporadic rains do not bulk largely in the total fall, from one to two years give a sufficiently good basis for a factor of correction to be applied with safety, provided that a long record is available at no greater distance than five to ten miles. In districts where the total fall is so small that a single thunderstorm may introduce great local variations, from four to five years' records are necessary. Variations in space are relatively easily applied with the help of an orographical map. A rainfall map is the best medium for computing the volume of rainfall over a gathering-ground as a whole, and the best and simplest method is by planimeter measurement.

THE WINDS OF HONGKONG.—A discussion under the direction of Mr. T. F. Claxton "to ascertain the difference in direction and velocity of the wind at the Royal Observatory, Kowloon, and at Victoria Peak, Hongkong, at different seasons of the year and at different hours of the day," has been issued by the Royal Observatory, Hongkong. The results are based on the records of Beckley anemographs for the period 1914-1918. The Royal Observatory is situated on a hillock, 100 feet high, about 1000 yards from the harbour; the surrounding country is flat, except to the north. Victoria Peak is 1840 feet above sea-level and is situated 3 miles to the south-west of the Royal Observatory. To the north, west, and south, the sides of the Peak are very steep, and the easterly winds are affected by the Hongkong hills. The anemograph records at the Observatory are measured at the half hours, and the value set against any hour is the run of the wind from 30 minutes before to 30 minutes after that hour. At Victoria Peak the records are measured at the hour, and the value set against any hour is the run of the wind since the previous hour. This difference in the method of registration seems likely to affect the results for comparison. Detailed hourly observations of direction and velocity are given for the two exposures for the years 1914–1918. The different situations naturally give different results, which are shown by numerous tables and diagrams. For normal wind results, for comparison with other world observatories, the results at Victoria Peak should probably be preferred, although both situations seem to leave much to be desired.

IONIC DISSOCIATION IN SOLUTION.—P. Debye and E. Hueckel have investigated the electrostatic forces between the ions of the solute, and the dipole action of the molecules of the solvent (*Phys. Zeits.*, May 1). They assume that the whole of the dissolved salt is dissociated; and for dilute solutions arrive at the equation

$$\theta = w\frac{\epsilon^2}{6\mathrm{D}k\mathrm{T}}\sqrt{\frac{4\pi\epsilon^2}{\mathrm{D}k\mathrm{T}}n\Sigma\nu_i}, \tag{1}$$

where θ, the deviation from the classical theory, $=(\Delta_k - \Delta_i)\Delta_k$, Δ_k being the lowering of the freezing point given by the classical theory and Δ_i that actually observed; w is a valency factor equal to $(\Sigma\nu_i z_i^2/\Sigma\nu_i)^{\frac{3}{2}}$. The dissolved molecule is split up into $\nu_1 - \nu_i - \nu_s$ ions of different kinds $1 - i - s$, with valencies $z_1 - z_i - z_s$, and w is calculated from these values; $\mathrm{T}=273$ when the solvent is water, $\epsilon = 4{\cdot}77 \times 10^{-19}$ e.s.u., n is Loschmidt's number $= 6{\cdot}06 \times 10^{23}$, $k = 1{\cdot}346 \times 10^{16}$ ergs, D, the dielectric constant, is 88·23 for water at 0° C., $\Sigma\nu_i = \nu$ is the number of ions into which a molecule of the salt splits up. Using these values,

$$\theta = 0{\cdot}270w\sqrt{\nu\gamma}; \tag{2}$$

and curves have been drawn showing the experimental relation between θ and $\sqrt{\nu\gamma}$ for a number of salts of varying constitution, including magnesium sulphate, lanthanum nitrate, potassium sulphate, and potassium chloride. These curves follow the straight lines obtained by giving w in (2) the proper values, for a considerable distance from the origin. For higher concentrations the deviations from the straight lines depend on the individual properties of the ions; and particularly on their dimensions, which were neglected in deriving (1) and (2). When the dimensions are taken into account, theory is found to agree very satisfactorily with experiment up to much higher concentrations. For very high concentrations other factors, previously neglected, have to be considered; there appears to be no doubt that, even in this case, the molecules of the solute are split into their ions.

STEREOSCOPIC PROJECTION.—Much attention has been directed in recent years towards obtaining a satisfactory method of stereoscopic projection. Many of the devices proposed involve the use by the individual observer of spectacles or binoculars with coloured glasses or interrupting shutters. The Daponte Stereoscopic Projector or "Pulsograph," which was exhibited by Mr. E. Sanger-Shepherd at the Royal Society Conversazione on June 20, employs an entirely different principle, whereby a "stereoscopic" effect can be readily observed by the unaided eye of the spectator. Two photographs are taken from two positions slightly separated, and projected in register on an ordinary screen by two optical systems. Between the source of light and the transparency in each of the optical systems a rotating shutter is placed, consisting of a glass disc with a graduated grey film varying from black at zero to clear at 180° and back to black at 360°. When one shutter is passing maximum light the other is at minimum transmission position, the rotating shutters dissolving the right-hand picture into the left-hand picture and *vice versa*. With the discs at the position of equal transmission, that is at the 90° position, a double-image picture appears, since the two stereoscopic photographs are not exactly alike; but on the discs being rotated the "stereoscopic" relief effect is immediately obtained. The "Pulsograph" can be employed for the projection of lantern slides, solid objects, or of kinematograph films.

Problems of Fundamental Astronomy.[1]

By Prof. W. DE SITTER, University of Leyden.

THE science of astronomy has, in the past twenty or thirty years, developed most remarkably. The marvellous applications of photography and spectroscopy on one hand, and the sudden growth of statistical stellar astronomy consequent upon the discovery of the two star-streams on the other, have led to so many unforeseen results and so many new points of view, that it almost appears as if the whole science were born anew and the astronomy of to-day had only very slight connexions with that of the last century: we are apt to think that the great problems of the past have lost all their interest to us. This, however, is not so. On the contrary, I think the central problems of fundamental astronomy have gained an enhanced importance even by the newest developments of the science.

Astronomy is essentially the science of space and time. It is not my intention, in thus assigning to astronomy this wide field, to annex to it the whole of physical science. On the contrary, I am quite content to consider astronomy only as a special branch of physics, but, having at its disposal the largest spaces and the longest times, it has generally had the last word in all important questions. To mention only a few cases at random: the discovery of gravitation, of the finite velocity of light, and of aberration, all these are astronomical discoveries, and the three crucial tests of Einstein's theory are all three astronomical.

In our exploration of space and time we are compelled to make all our measures from this earth, to which we are tied, as a starting-point. The problems of fundamental astronomy are those which arise from this fact, that all our observations are necessarily referred to a moving origin. These problems are, from their nature, not very liable to change of aspect with time or fashion; they are essentially the same to-day as they were in the time of Hipparchus, the founder of astronomy, and they will remain the same so long as science lasts, and will require ever more accurate and more complete solutions, as we penetrate more deeply into the constitution of the universe. Fundamental astronomy thus consists essentially of a scrutiny of the last decimal place. This striving after extreme accuracy, this fidgeting over small quantities, may appear uninteresting, or even pedantic. But we must not forget that great problems always turn about the measurement of small quantities.

The problems of fundamental astronomy are, of course, all interconnected with each other, but, for the sake of clearness, they may be classified under three heads. There are, first, the problems connected with the system of constants. The motion of the earth, and the system of measurement based on it, are defined by several numbers, such as the solar parallax, the constants of precession and nutation, the ellipticity, the mean radius and the mass of the earth, etc. Between these several constants there exist relations, connecting two or more of them with each other and with other universal constants such as the velocity of light and the constant of gravitation. The problem here is essentially one of adjustment, so as to get a consistent set of constants satisfying all the connecting relations. The set of constants in actual use in the national ephemerides is not consistent. The discordances are, however, not very large, and changes should not be introduced unless by general international agreement.

[1] Synopsis of a lecture delivered at the Imperial College of Science and Technology, South Kensington, on May 7.

Another set of problems are those connected with the rotation of the earth. The paramount practical value of this rotation is that it is used as our standard measure of time.

Time is measured by observing the changes occurring in some physical system—*i.e.* in the relative positions of some material bodies, which positions at any time are determined by our theories, so that from the observed positions we can infer the time. Such a mechanism—by preference periodic—that is used to measure time may conveniently be called a "clock." But there is no absolute measure of time, nor an absolute test of the accuracy of any clock; we can only test one clock by another. If the two do not give the same time, then one or both must be wrong, *i.e.* our theories of the mechanism of one or both must be incomplete. The standard clock to which all others are generally referred is the rotating earth. Is this standard absolutely trustworthy? Do all observatories give the same time, and if so, is this a truly uniform time? In other words: does the earth rotate as a rigid body, and if so, is this rotation strictly uniform?

It has long been suspected that the earth's rotation is very gradually slowing down, owing to the friction of the tidal wave.[2] But lately other doubts have arisen as to the trustworthiness of our universal standard. As a matter of fact, it is not the rotation of the earth, but the rotation of a definite point on the earth—Greenwich Observatory or any other observatory—that is used as our standard, and now that the wireless distribution of time signals has made comparisons so easy, occasional discrepancies between the times of different observatories, amounting sometimes to several tenths of a second, have come to light.[3]

It appears probable that these are due to errors in one or more of the parts of the mechanism used to determine the time at some or all of the observatories—the transit instruments, the clocks, the astronomers—but it also may be that they are due to real differences in the rotation of the different observatories, which would mean that the earth does not rotate as a rigid body, but some parts of its surface are moving relatively to other parts.[4] Here evidently is a most important problem, the solution of which must be found sooner or later.

Besides the rotating earth, we have other "clocks," of which the moon must be mentioned in the first place. It is well known that in the motion of the moon there are irregularities of a much longer period, called "fluctuations" by Newcomb, for which no explanation has yet been found. Brown[5] and Glauert[6] have pointed out similar irregularities in the motions of the sun, Venus, and Mercury. If this were confirmed, and if also other bodies—especially Jupiter's satellites—should show the same thing, then it would become very probable that the true origin of these fluctuations is in the rotation of the earth, or at least of the outer crust of the earth.

Other problems connected with the rotation of the earth, and the question whether it rotates as a rigid body, are those involved in the variation of latitude.

[2] Taylor, Mon. Not. R.A.S. lxxx. 308; Jeffreys, *ibid.* 309.
[3] Sampson, Mon. Not. R.A.S. lxxxii. 215; Dyson and Bowyer, *ibid.* lxxxii. 193.
[4] Dr. Innes (Johannesburg Circular 55) has recently directed attention to irregularities in the moon's motion of the same character as the discordances between the times of different observatories referred to above. But these are derived from several observatories, giving concurrent results, so that it would appear that the error is in the moon, and not in the time.
[5] Brit. Assoc. Report, Australia, 1914.
[6] Mon. Not. R.A.S. lxxv. 489.

There seems to be evidence[7] of sudden as well as slow and continuous changes, which, if they are real, may be due either to shifting of parts of the crust of the earth relatively to each other, or to a slow sliding of the whole of the crust over the core.

All these problems, which evidently are of the greatest importance not for astronomy alone, depend for their solution on very small quantities which even now only begin to come within the reach of our most accurate measures and most refined discussions.

The third set of problems of fundamental astronomy concern questions relating to the positions and motions of the fixed stars. Bessel's great work called "Fundamenta astronomiae" consists of a careful discussion and synthesis of the observations made by James Bradley as Astronomer Royal at Greenwich upon the positions of the stars.

Indeed, the positions and motions of the "fixed" stars are the basis on which the whole structure of astronomy rests. The manner in which these positions are determined is forced upon us by our location on the moving earth. The accumulated labours of astronomers since the commencement of accurate observing by Bradley have resulted in a system (or rather three systems, differing by small, but not negligible, quantities) of positions and motions of the stars. These are referred to a frame of reference, which is defined by the motion of the earth, and consisting of the equator, and a zero point on it. Both the equator and the zero point are moving. It need scarcely be stated that the formation of such a system of positions and motions of stars is a most intricate and difficult problem, and we must confess that it has not, so far, been solved in a manner which satisfies the demands of statistical astronomy and cosmogony.

The system which is generally considered the best of those now in use, that of Boss, is by no means perfect: large errors in it are not at all improbable.[8] These errors are errors of the system, not of the individual star-positions, and the question naturally arises: Is an "absolute" system at all necessary? Strictly absolute, of course, it is not: all systems of reference are relative. By "absolute" we mean relative to the inertial frame defined by the motion of the earth in the solar system. But is it necessary to base our system of star-positions on this motion of the earth? Would it not be much more natural, and much more simple as well, to have relative positions and motions of the stars with regard to one another, or to the general average of them?

Many astronomers are inclined to answer this question in the affirmative, and to consider the absolute system more as a time-honoured institution of our predecessors, a venerable relic from the pre-photographic days, than as a useful and necessary adjunct of modern stellar astronomy. In fact, by the application of photography, we can easily derive relative motions, or motions of individual stars relatively to the "background," with an accuracy which many times exceeds that attainable by fundamental methods.

By the blink-microscope we find, with comparatively very small labour, proper motions of very satisfactory accuracy referred to the background of faint stars in the area examined. Of course this "background" is a rather loosely defined frame of reference, and we have no guarantee that the motions of stars in different areas of the sky are really referred to the same frame. A more elaborate method of referring the relative motions determined photographically to a quasi-absolute system is proposed by Kapteyn.[9] This method, however, depends on the hypothesis that the sun's motion relative to faint stars is the same as that relative to bright stars. This is why I call it a "quasi-absolute" system. Are not the proper motions derived by these and similar methods quite as valuable as those found by fundamental methods?

My answer is decidedly in the negative. We cannot do without the "absolute" system of fundamental astronomy. The value of that system is not that it is attached to the earth, but that we know exactly what the frame of reference is and that it is a rigorous system, giving certainty that all motions are really referred to the *same* frame. To see the importance of this, I will put some questions, which cannot be answered until we have a fundamental system including the faint stars.

Is star-streaming a universal phenomenon, or is it local, and in the latter case, how far from the sun does it extend? Do the Orion-stars take part in the star-streaming or not? Is there a systematic motion of faint stars relatively to bright stars; or in other words, is the average motion in space of the stars independent of their brightness?[10] Is there a rotation of the system of stars as a whole?

These and similar questions are again examples of great problems the solution of which depends on very small quantities. These small quantities, the proper motions of faint stars, cannot be profitably discussed unless we have the certainty that these motions are referred to a rigorous system.

The necessity of a fundamental system being granted, we must next ask: how are we to improve and extend our present system? Must we, in order to establish an absolute system, necessarily retain the old methods, or can we find other means? Is the meridian instrument to remain the only one by which star places are to be determined? To this question I wish, as emphatically as to the former one, to answer in the negative. We must look for other methods, if it be only to verify the results from the meridian work.

Here I think is the greatest problem, and the most urgent problem, of fundamental astronomy. It is twofold: the determination of the positions of the stars, and that of their motions. We must thus not only establish a rigorous and faultless system of star positions for the present day, but also strengthen as much as possible our knowledge of the positions in the past. These latter as now used depend practically exclusively on Bradley's observations. But there are other data available, though not yet, or not yet sufficiently, reduced. Among these the most important are the rich mine of material still lying unused in the observations made in the last quarter of the eighteenth century and the first quarter of the nineteenth by Hornsby and Robertson at Oxford.[11] I think the careful reduction of these observations, which are of the same excellent quality as those of Bradley, is one of the most urgent demands of fundamental astronomy.

As to the means by which the modern positions must be determined, I will not attempt now to enter into details regarding the methods which have been, or may be, proposed to supplement the classical meridian methods. All I wish is to convey an idea of the meaning and the importance of the problems of fundamental astronomy, and to show that far from being uninteresting remains of a past period, their solution has become even more urgent by the newest developments of several branches of modern astronomy.

[7] Lambert, U.S. Coast and Geodetic Survey, Serial No. 183, giving many references to other papers.

[8] See *e.g.* Kapteyn, B.A.N. 14.

[9] Groningen Publications, 28.

[10] A considerable difference in average velocity would arise if the percentage of high-velocity stars (cf. Oort, B.A.N. 23) were not the same for all magnitudes.

[11] See Rambaut, Mon. Not. R.A.S., lx. 265.

Night Temperature on Mt. Etna.

THE observatory on Mt. Etna is perched high up on a plateau of the volcano known as the Piano del Lago beneath the summit ridge, which rises about 1000 feet higher. It is sometimes noticed by the officials, who only reside a few days in each month, that a curious rise in temperature, amounting to a couple of degrees or so centigrade, occurs during the middle of the night, constituting a well-marked secondary nocturnal maximum in the diurnal variation of temperature. During a visit to the station in August 1920, Prof. Filippo Eredia noticed that the nocturnal inversion in the regular fall of temperature was associated with the arrival of sulphurous fumes from the crater, but notwithstanding the contemporaneous occurrence he does not attribute much causal connexion between the two phenomena. A dozen cases, as shown by thermograph records, are discussed by him in a paper contributed to vol. 31 (1922) of the Rendiconti della Reale Accademia Nazionale dei Lincei. Most of them occurred in the summer, and in conditions both of calm and of wind of different forces and directions, chiefly N.E. and N.W. The calm cases with clear sky are shown to be analogous to similar nocturnal inversions in other mountain regions, and are attributed partly to the slow descent of air from the summit ridge whereby it is warmed by adiabatic compression, and partly to the latent heat of misty condensation due to the previous general nocturnal chilling of the atmosphere. This, however, is not quite convincing; the effects are too complex to be explained on a purely qualitative basis. The cases with strong wind are found to be associated with a great difference of temperature between the interior of Sicily and the eastern flanks of Etna, giving rise to a circulation which carries warmer air to the high-level station. At Catania on the coast near sea-level there are no corresponding night inversions of the diurnal range of temperature.

Although the above are only examples of secondary night maxima, the inversion of the regular variation not being nearly marked enough to override the primary day maximum in 24 hours, it is probable that in the latitude of Sicily, where the range of temperature between day and night is at all seasons large, such minor irregularities in the diurnal course of temperature attract more attention than they would in a higher latitude, where during the very short days of winter the diurnal range is small and liable to be obliterated, or even occasionally entirely inverted, by the very rapid and conspicuous irregular variations of temperature. In England, for example, during the month of December it is no very rare event for night to be warmer than day: for should frosty air begin towards evening to be replaced by a warm, humid current from the Atlantic, not only will the frost be swept away, instead of intensified, as night comes on, but the thermometer may easily rise to 50° F. or above in the middle of the night.

L. C. W. B.

The School of Hygiene in London.

AN inquiry at the Ministry of Health relating to the proposed School of Hygiene in London has elicited the following statement of the position of the scheme.

In May 1921 the committee on Post-Graduate Medical Education, under the chairmanship of the Earl of Athlone, published its report, recommending, *inter alia*, the establishment of an Institute of Medicine in association with the University of London, in which instruction should be given in public health and other departments of medicine. This suggestion was further explored by a small Departmental Committee and detailed proposals were formulated.

The University of London and the Government were, however, unable to find the money to establish an Institute of Medicine such as Lord Athlone's Committee had contemplated, and in these circumstances the proposals were brought to the notice of the trustees of the Rockefeller Foundation, whose representatives had recently been in consultation with the authorities in Great Britain. The trustees of the Foundation generously agreed to provide two million dollars for the establishment of the Institute, to be called the School of Hygiene, the British Government undertaking to make an annual grant towards the upkeep of the School. Preliminary work was undertaken for the preparation of plans and estimates, and a site has been selected.

It has been decided that the School when established shall be affiliated with the University of London but managed by a separate governing body, for which a charter of incorporation will be sought. Pending the presentation of a petition for the charter, the Minister of Health, with the concurrence of the trustees of the Rockefeller Foundation, has appointed a transitional executive committee. The functions of the committee will be to appoint a director, to arrange for amalgamation or co-ordination between the School and other institutions working in similar or closely related spheres, to prepare plans for the new School, and to begin building, unless in the meantime it has been possible to set up the permanent governing body. The members of the committee are: The Rt. Hon. Neville Chamberlain (chairman), the Rt. Hon. the Viscount Burnham, Capt. Sir Arthur Clarke, Sir Walter Fletcher, Lieut.-Col. Fremantle, Sir Harry Goschen, Sir George Newman, Sir Cooper Perry, and Sir Arthur Robinson, with Mr. L. G. Brock, of the Ministry of Health, as secretary.

University and Educational Intelligence.

ABERDEEN.—At the Summer Graduation on July 11, the honorary degree of LL.D. was conferred on Prof. J. Fraser, Jesus professor of Celtic in the University of Oxford.

Mr. William Thomas received the degree of Ph.D. for theses on (*a*) The influence of colloids on reactions involving gases, and (*b*) Inorganic complex salts.

The following prizes were awarded: Collie prize in botany and Sutherland gold medal in forestry to Mr. J. H. Hunter; Struthers medal and prize in anatomy to Mr. J. W. Foster; Lizars medal in anatomy to Mr. J. W. Foster and Mr. A. J. W. Wilkins; John Murray medal and scholarship in medicine to Mr. A. Lyall.

The University Court has decided to make first appointments, in the coming autumn, to the newly founded chair in engineering and to the Cruickshank lectureship in astronomy and meteorology.

CAMBRIDGE.—Mr. D. C. Carroll, Trinity Hall, has been elected to the Michael Foster research studentship; Dr. C. C. Worster-Drought, Downing College, has been elected to the E. G. Fearnsides research scholarship.

LONDON.—At a meeting of the Senate held on July 18, the title of reader in organic chemistry was conferred on Dr. O. L. Brady, of University College;

and the title of emeritus professor on Prof. W. D. Halliburton, on his retirement from the chair of physiology at King's College, which he has held since 1890.

The degree of D.Sc. (*Chemistry*) was conferred on Mr. Jnanendranath Mukhopadhyay (University College) for a thesis entitled "The Adsorption of Ions and the Precipitation of Suspensoids by Electrolytes."

St. Andrews.—The Senatus Academicus will, on the occasion of the installation of Mr. Rudyard Kipling as rector of the University, on October 10, confer the honorary degree of LL.D. on Sir James G. Frazer, author of the "Golden Bough," and on Sir John Bland-Sutton.

Twenty-five years ago the Medical School of the University was re-organised, and Dr. A. M. Stalker was appointed the first professor of medicine under the new conditions. The successful development of the School owes much to Prof. Stalker's great abilities, to his personality, and to his veneration for the University of his adoption. Prof. Stalker having intimated his resignation of the chair of medicine, the Senatus Academicus recorded a special minute expressing appreciation of his loyal service.

The University Court has decided to proceed with a scheme for building additional storeys to the existing teaching laboratories for physics and chemistry and connecting the two by a central building.

The University of Wales has conferred the honorary degree of D.Sc. upon Sir Charles Sherrington.

The following awards tenable at the Imperial College of Science and Technology, South Kensington, during the year 1923–24 have been made:—By the governing body of the College: (*a*) The Henry George Plimmer Fellowship in Pathology to Mr. H. R. Hewer, for research on "The Rôle of Stimuli received by the Eye in the Colour Changes of Amphibia and Nerve Supply of the Pituitary," value about 300*l.*; and (*b*) The Gas Light and Coke Company's Research Fellowship, just established by the Company for the purpose of encouraging experimental research in relation to carbonisation, gaseous fuels and combustion, to Mr. F. R. Weston, for "The Spectroscopic Investigation of the Flames of Carbon Monoxide and Hydrogen and matters cognate thereto," value 175*l.*, together with an allowance towards the expense of the research. By the Trustees of the Beit Fellowships for Scientific Research: Research fellowships to Mr. H. W. Buston, for a continuation of his work on the "Nitrogenous Metabolism in Plants," and to Mr. O. M. B. Bulman, for research on "Stratigraphical Geology: The Fauna of the Shineton Shales," value 250*l.* per annum each.

The coming of age of the Manchester Municipal College of Technology was celebrated on July 5 and 6 by a soirée each evening in the College buildings. The guests were received on the first evening by Viscount Burnham, the Lord Mayor of Manchester, and Alderman West. After the reception Viscount Burnham addressed the gathering and congratulated the city of Manchester on having an institution which, while forming a Faculty of the University, was in touch also with the industries of the district. He spoke of the constantly increasing need for the application of science to industry, and of the importance of selecting appropriate occupations for young people starting work. He saw in the College an efficient instrument for achieving these purposes. Among other distinguished people, Viscount Burnham was supported by the Vice-Chancellor of the University, Mr. Mouat Jones, principal of the College, and Mr. J. H. Reynolds, who was the first principal of the College. The guests were each presented with an illustrated pamphlet, "An Historical Account of the Origin and Development of the Municipal College of Technology, Manchester," written by Mr. Reynolds. The whole of this striking souvenir was produced in the Printing and Photographic Technology Department of the College.

As a mark of appreciation of Sir Michael Sadler's stimulating work for the University of Leeds during the twelve years in which he has held the office of Vice-Chancellor, it has been decided to establish a memorial in the University in the form of his portrait and a fund for assisting necessitous students. Subscriptions—restricted to 5*l.* in an individual gift—are invited for these purposes. In Yorkshire, and to past and present members of the University, the results of Sir Michael Sadler's devoted work for the development of the University are richly manifest, and the response to the appeal is sure to be ready and generous. There are in addition many who hold Sir Michael in the highest esteem, on account not only of his labours as Vice-Chancellor but also for his untiring activities on behalf of educational freedom and growth in institutions of all grades. He has been the uncrowned leader of education in England—indeed, in the Empire—for a generation, and the opportunity of expressing regard for what he has done will be widely welcomed. Contributions should be made payable to the Treasurer of the Sadler Fund and sent to the University, Leeds.

The Universities of Oxford and Cambridge Bill to give effect to recommendations in the report of the Royal Commission of 1919–22 was read a third time in the House of Commons on Friday, July 20. The Bill provides that there shall be two bodies of Commissioners, one for each University, and directs them to make statutes and regulations in general accordance with the recommendations of the Royal Commission, but with such modifications as may appear expedient. The Universities are given the power independently of the colleges to prescribe what contribution should be made by the colleges for university purposes. The provisions of the Act of 1877 are modified, so that trusts less than sixty years old can be altered with the consent of the trustees. The Marquis of Bath, in moving the second reading, remarked that if it were necessary to reduce the amounts of the grants recommended by the Royal Commission, cuts would have to be made proportionately from the amounts for general purposes, for libraries, for women's colleges, and for extra-mural boards. On the motion for the third reading, Mr. J. R. M. Butler proposed an amendment amounting to a direct instruction to the Commissioners to take action by giving women full membership at once of the University of Cambridge. It was pointed out by the president of the Board of Education that it made a very considerable difference whether having appointed a number of distinguished men to control the working of a university they resolved that the House of Commons should limit their discretion. The amendment was rejected by 150 votes to 124. An amendment providing that, in making any statutes or regulations, the Commissioners should have regard to the need of facilitating the admission of poorer students to the Universities and colleges, was agreed to. The list of Commissioners includes the names of Sir A. E. Garrod, Sir T. L. Heath, Sir R. T. Glazebrook, and Sir H. K. Anderson.

Societies and Academies.

LONDON.

The Faraday Society, July 2.—Prof. A. W. Porter, past-president, in the chair.—A. **Ferguson**: On a relation between surface tension and density. Macleod has shown empirically that for a number of unassociated liquids, $\gamma = C(\rho_l - \rho_v)^4$, where γ is the surface tension of the liquid at any temperature, $\rho_l - \rho_v$ the difference between the orthobaric densities of the liquid and the vapour at that temperature, and C a constant which is independent of the temperature. This expression is referred to the power law connecting surface tension and temperature first put forward by van der Waals but not generally known, and the Eötvös equation.—U. R. **Evans**: The law of definite proportions in the light of modern research. Many of the series of solid solutions met with in alloys show a maximum *melting-point* (*i.e.* a maximum *thermal stability*) at a composition indicated by a simple atomic formula (*e.g.* AuMg); it is customary to describe this member of the series as an "inter-metallic compound," and to regard it as the parent of the series. But in cases where there is a maximum *hardness* (*i.e.* maximum *mechanical stability*) at a composition indicated by a simple atomic formula (*e.g.* AgAu), or where there is an abrupt change of chemical behaviour (a *parting limit*), it is not at present customary to apply the word "compound." The fact that the maximum stability usually occurs at a composition expressible by a simple formula is often capable of a physical explanation. Many of the oxides of metals with more than one valency have a variable composition; *e.g.* pure Fe_3O_4 and Fe_2O_3 may be regarded as the "end-members" of a series. Likewise homogeneous bodies of variable oxygen-content occur among the oxides of platinum, iridium, nickel, molybdenum, tungsten, and possibly silver, lead, and thallium. Chlorides of thallium, sub-chlorides and sub-bromides of bismuth, and sulphides of copper, nickel, and cobalt show similar series of homogeneous substances.—J. **Grant** and J. R. **Partington**: Concentration cells in methyl alcohol. The E.M.F. of concentration cells formed from solutions of silver nitrate in methyl and ethyl alcohols as determined by Wilson agrees with that calculated from Nernst's formula only for the latter. Good agreement has been found, however, in both cases.—F. G. **Tryhorn** and S. C. **Blacktin**: The formation of anomalous Liesegang bands. Two examples of the production of anomalous Liesegang bands are cited in addition to the case of lead chromate in agar gels first noticed by Hatschek. The substances formed crystallise from the respective gels more readily in the light than in the dark.—J. B. **Firth**: Determination of the density of charcoal by displacement of liquids. It has been shown that the apparent densities of cocoanut shell charcoal and sugar charcoal have been determined after definite intervals, for several liquids. The values obtained increase with the time of contact between the liquid and the charcoal. Further, the final density value varies with the different liquids. It would appear that the rate of change in the density value and also the final density will be determined by the rate of sorption and sorptive capacity respectively.

EDINBURGH.

Royal Society, June 18.—Prof. F. O. Bower, president, in the chair.—F. **Walker**: The igneous geology of the Dalmeny district. The igneous rocks of the Dalmeny district may be divided into three groups:—(1) Basaltic lavas of Dalmeny type which are of undoubted Lower Carboniferous age. (2) A suite of sills which bear analcite and occasionally some nepheline. These sills are probably to be reckoned as the underground manifestation of Lower Carboniferous volcanic activity. (3) A group of quartz dolerite sills which belong to a later phase of intrusion and appear to be connected with Permo-Carboniferous earth movements. The second group contains some interesting petrographical types including teschenite, camptonite, and theralite. All three types are represented in the Mons Hill sill, which is of great complexity.—Miss Elizabeth **Gilchrist**: The slow oxidation of phosphorus. Phosphorus glows in air but not in oxygen at high pressures; some gases act as poisons while others act as promoters of the glow. The reaction appears to take place in two stages; phosphorus trioxide being produced in the first stage without glowing, and phosphorus pentoxide in the second stage with glowing. The hindering effect is ascribed to the production of an anticatalyst, which probably consists of negatively charged molecules.—G. A. **Carse** and D. **Jack**: On the X-ray corpuscular emission from iron in a magnetised and unmagnetised state. According to Ewing's theory of magnetism there is something in the iron atom that turns in response to an applied magnetic field. Experiments on the X-ray corpuscular emission from iron in a magnetised and unmagnetised state show that in the iron atom either the part that turns does not emit an appreciable number of electrons or the chance of ejection is not affected by the orientation.—Lancelot **Hogben**: The mechanism of amphibian colour response. The pituitary gland of mammals, birds, reptiles, amphibia, and fishes contains a substance which exercises a highly specific effect upon the melanophores of amphibia, inducing a condition of maximal expansion which is not precisely simulated by other drugs or tissue extracts, which agree in their action on plain muscle with pituitrine. The action of pituitary extract on melanophores is local and direct. Like other pituitary antacoids, the melanophore stimulant is destroyed by trypsin. Like the oxytoxic principle, it is more stable to acid hydrolysis than the pressor substance, and is mainly located in the posterior lobe of the fresh mammalian gland. After removal of the pituitary (whole gland) in both adult frogs and larval salamanders, the melanophores remain permanently in a state of maximal contraction, even when the animals are exposed to optimum conditions for producing pallor. When injected with pituitary extracts they expand fully; but the animals regain pallor even under exposure to those conditions which invariably produce melanophore expansion in normal or partially hypophysectomised animals. The evidence for a direct nervous control of amphibian colour response is inadequate. Pituitary secretion fluctuates in correlation with conditions which evoke pigmentary change.

SHEFFIELD.

Society of Glass Technology (Leeds meeting), June 20.—W. E. S. **Turner**: Specifications in the glass industry. Certain types of glass, such as that used for optical purposes, are bought on specification and must conform strictly to certain properties. In the case of containers for liquids and solids, no attempt is made to manufacture or purchase on the basis of specification. If the glass industry insisted on furnace material makers providing, for example, refractories to specification, then the glass manufacturers themselves should at least show they are prepared to supply their own goods to specification.—Th. **Teisen**: Notes on the design of pot arches. Modern types should contain good facilities for heat distribution and control; they should also combine good conditions for working and firing with easy installation and economy of space. In one type described, water is kept dripping on the firebars and on a plate arranged in front of them, thereby producing a certain amount of steam; this helps to retard the drying of the surface parts and allows the inside to evaporate its moisture at the same rate as the outside. This type takes up little space with proportionately less building cost, and results in practice are satisfactory.—S. **English**: Notes on the Ashley bottle machine. To one familiar only with modern glass-forming machines, it is surprising to learn that the home of bottle-making machinery is on this side of the Atlantic. The first machine to make narrow-mouth bottles at all satisfactorily was designed and built by H. M. Ashley at Ferrybridge (Yorkshire), about 1886.

PARIS.

Academy of Sciences, July 2.—M. Albin Haller in the chair.—Auguste **Béhal**: The fourth International Congress of Pure and Applied Chemistry. An account of the conference held at Cambridge on June 16-21.—Ch. **Gravier**: The adaptation to tree life of a Madagascan crab.—Henri **Villat**: A singular integral equation and a problem in the theory of vortices.—J. B. **Senderens**: The manufacture of ethyl and methyl ether. A study of the conditions (temperature and strength of sulphuric acid) for maximum yield of these ethers from their respective alcohols. For methyl ether, with sulphuric acid of the strength $H_2SO_4 . 2H_2O$ and at a temperature of 160° C.-165° C., the ether can be made continuously at the rate of 250-300 c.c. per minute.—Bertrand **Gambier**: The curves of Bertrand and the deformation of quadrics.—Richard **Birkeland**: The resolution of algebraic equations by a sum of hypergeometric functions.—J. **Haag**: Certain particular states of a gaseous mass, agreeing with Maxwell's law.—A. **Lafay**: The arborescences traced out by the positive silent discharge.—Félix **Michaud**: The electrical properties of jellies. In an earlier communication the author showed that a jelly, when traversed by an electric current, contracts at the anode and swells at the cathode. From this it follows that a jelly submitted to a pressure gradient should show potential differences. This conclusion is verified experimentally.—F. **Wolfers**: The deviation of the X-rays at the surface of bodies, and the effects produced by a slit.—A. **Lepape** and A. **Dauvillier**: The fine structure of the limits of high-frequency absorption. The L limits of xenon.—M. **Marsat**: A combination of reflectors. An account of an optical arrangement of mirrors for use on motor cars, satisfying the condition that a beam should be cast at least 100 metres in front of the car, but with no dazzle at a height more than one metre from the ground.—Xavier **Waché**: Quantitative researches on the ultra-violet spectrum of copper in aluminium. With aluminium containing 5 per cent. of copper, 35 copper lines were photographed for wave-lengths between 2179 and 3274 international units. Alloys containing 1, 0·5, 0·2, 0·05, 0·01, and 0·005 per cent. of copper (in aluminium) were examined with the same Hilger spectrograph, and the gradual disappearance of the lines shown. For the 0·005 per cent. alloy only the two lines 3247·5 and 3273·9 remained.—A. **Marcelin**: The isothermal compression and expansion of superficial solutions. By superficial solutions is meant such systems as a monomolecular layer of oleic acid on water. Two forms of apparatus are described for measuring the changes in the surface tension.—M. **Holweck**: A helicoidal molecular pump. A description, with diagram, of a modified form of Gaede pump, with details of the results obtained by it.—E. **Carrière** and **Cerveau**: Determination of the boiling-point and dew-point curves of mixtures of hydrobromic acid and water under a pressure of 760 mm.—E. **Darmois**: Polarimetric observations on tartar emetic, and tartrate and malate of uranyl. The precipitation of antimony oxide from ordinary tartar emetic solution by the gradual addition of potash has been followed by means of the polarimeter. The first reaction is the precipitation of Sb_2O_3 and formation of potassium tartrate: beyond a certain point the addition of more potash leads to the formation of a new lævorotatory compound, not yet isolated. The same method applied to the study of uranyl tartrate and malate leads to the conclusion that complex acids resembling tartar emetic are formed.—Mme. N. **Demassieux**: The equilibrium between lead iodide and the iodides of potassium and ammonium in aqueous solution.—F. **Bourion** and E. **Rouyer**: The association of mercuric chloride. From a study of the rise of the boiling point of solutions of mercuric chloride of varying concentration, evidence of the existence of the molecule $(HgCl_2)_3$ has been obtained.—André **Job** and René **Reich**: The existence of organo-magnesium compounds containing arsenic.—L. **Hackspill** and G. **de Heeckeren**: A new volumetric method of elementary analysis. The organic compound is burnt with copper oxide in a silica tube *in vacuo*, the water formed condensed at − 80° C., and the carbon dioxide and nitrogen pumped out and analysed. The water is afterwards allowed to react with calcium hydride, and the hydrogen measured. In this way the whole operation is reduced to a gas analysis.—Paul **Woog**: The hydration of hydrocarbons. The carefully dried oils were allowed to take up moisture from moist air, and the amount of water taken up was measured by the resulting change in the electrical conductivity. Difference in the amounts of water taken up under these conditions was observed for different classes of oil.—F. **Ehrmann**: Discovery of evidence of the Tyrrhenide in the region west of Bougie (Algeria).—G. **Pontier**: The fossil elephants of England: the presence of *Elephas trogontherii* at the extreme base of the forest bed of Cromer.—Pierre **Dangeard**: Remarks on the state of the oil in the interior of oleaginous seeds.—L. **Blaringhem**: The mosaic of the sexes in a hybrid of wild sorrel (*Rumex Acetosa* × *R. scutatus*).—Emile **Haas**: Experiments on the states of regional and relative adaptation of the retina.—Emile **Devaux**: The pace of development in interfecundity.—A. **Pézard** and F. **Caridroit**: Gynandromorphism in the Gallinaceæ.—Anna **Drzewina** and Georges **Bohn**: Retarded effects of the dilution of the sperm on the development of the egg of the sea urchin.—Edouard **Chatton** and André **Lwoff**: The evolution of the Infusoria of the lamellibranchs. The primitive forms of the phylum of the thigmotrichs: the genus Thigmophrya.

Official Publications Received.

The Animal Products Research Foundation of the University of Adelaide. Second Annual Report, 1922. Pp. 6. (Adelaide.)

City and Guilds of London Institute. Report of the Council to the Members of the Institute, 1923. Pp. liii+89. (London: Gresham College.)

Sudan Government: Scientific Research Committee. Report of the Committee for the Year 1922. Pp. 9. (Khartoum: Sudan Printing Press.) 2 piastres; 5*d*.

The Institution of Civil Engineers. Engineering Abstracts prepared from the Current Periodical Literature of Engineering and Applied Science, published outside the United Kingdom. Edited by W. F. Spear. Supplement to the Minutes of Proceedings of the Institution. New Series, No. 16, July. Pp. 219. (London: The Institution of Civil Engineers.)

Bishops Stortford College. Report of the Proceedings of the Natural History Society, 1922. Pp. 16. (Bishops Stortford.)

Technical College, Bradford, Diploma and Special Day Courses. Prospectus, Session 1923-24. Pp. 189+26 plates. (Bradford.)