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Airships and Arctic Meteorology.

IN recent years great advances have been made in our knowledge of the atmosphere. The increase in the number of observatories and the transmission of meteorological data from ships at sea have made material contributions to these advances. There are, however, still large areas of sea and land of which our knowledge is altogether inadequate for the advancement of science. Nowhere are there more significant gaps in the desirable network of stations than in polar regions. Observatories exist in Greenland, Jan Mayen, Spitsbergen, Novaya Zemlya, and Alaska, but throughout the length of Arctic Siberia and in most of Arctic Canada there are great areas from which no continuous series of observations are obtainable, and even the geographical features of a large part of the Arctic Ocean are unknown. The most northerly observatory is the Norwegian station at King's Bay, Spitsbergen. North of latitude 80°, there is not a single observatory, and even scattered data from the inner or ice-bound Arctic regions are very few and incomplete. In a recent lecture to the Royal Geographical Society, Dr. G. C. Simpson, the director of the Meteorological Office, said that little further advance in polar meteorology can be made by spasmodic meteorological observations. The short series of data brought back by exploring expeditions engaged primarily in other branches of work are not of great value. Permanent observatories alone can supply the want, and if these are provided with wireless, they can not only extend the area of the synoptic charts used in forecasting, but also reduce the area of the unknown for other general purposes of the science.

Within the last three years an International Society for the Exploration of the Arctic Regions by means of Aircraft has been established, with its headquarters in Berlin and with Fridtjof Nansen as president. National groups of members of the Society are in process of formation in many countries. One of the chief aims of the Society is the foundation of meteorological and magnetic observatories in high latitudes in Arctic regions. ' Aeroarctic ', to give the society its shorter title, has also other aims, but those relating to meteorology and magnetism are at present in the forefront. The older means of transport, ship and sledge, have so far only allowed difficult and spasmodic advances into the ice-bound areas of the Arctic basin, and the uncertainty of these means of transport, dependent as they are on the variations in the ice-cover from year to year, are prejudicial to the maintenance of permanent stations in high latitudes. The Society believes that the difficulties and uncertainties of Arctic transport can be overcome only by aircraft. The aeroplane is considered to be less useful than the airship. High speed is of less importance than carrying capacity and power to land without extensive ground preparations.

The programme that the Society has in hand is ambitious; and it will not fail to evoke criticism. The presidency of Dr. F. Nansen and the support of many eminent meteorologists and polar experts throughout Europe and America is, however, a guarantee that the plans have been carefully considered. It must never be forgotten that it was Dr. Nansen who, nearly forty years ago, dared to defy the accepted canons of polar travel and the advice of nearly all polar experts in his daring and successful voyage in the *Fram*. Once again he is in the forefront in adopting new methods of locomotion.

The Society hopes to obtain the use for the spring of next year of the German airship *Graf Zeppelin*, and under the direction of Dr. Nansen a series of preliminary flights are projected. Difficulties have arisen on account of the crew having expressed unwillingness to take polar flights in the airship. The plan proposed is for three flights—the first is to be from Murmansk to Alaska via the north of Spitsbergen, Greenland, and the Beaufort Sea; the second is to be a flight round the unknown Beaufort Sea; and the third is to be from Alaska along the edge of the continental shelf north of Siberia via Nicholas or Northern Land to Murmansk. These are regarded as preliminary flights to settle definitely a few problems regarding the possible existence of unknown land, to investigate possible sites for permanent observatories, and to map the edge of the continental shelf. For the last purpose a form of sonic sounder dragged along the surface of the water will be used.

The Society hopes eventually to found observatories in Nicholas Land, Peary Land (Greenland), Grant Land (Ellesmere Island), and Banks Island, and to arrange for these to be relieved annually by airship. A further and more daring plan is to found observatories on the drifting pack-ice of the Arctic Sea, connected by wireless so that their daily position might be determined. It is calculated that the gross weight of such a station-building with food and fuel for two years would be about twenty-five tons. This, in addition to the weight of men and dogs, could be carried by an airship of sufficient size into any part of the Arctic regions. Lastly, the Society hopes to encourage the foundation of observatories on various Arctic lands accessible by sea, such as Franz Josef Land, the New Siberian Islands, the Siberian coast, and the Arctic Islands of Canada. It is hoped that the task of founding and maintaining these observatories would be undertaken by the States to which those territories belong.

The whole scheme is a daring experiment. Some people may even call it rash. But if it succeeds, even in part, it should result in considerable additions to knowledge. Amundsen and Nobile crossed the Arctic in an airship three years ago. Since then great improvements have been made in airship construction, and the *Graf Zeppelin* this year made a successful flight round the world, through many difficult weather conditions. It is true that last year the *Italia* airship came to grief in Arctic regions, but the *Italia* was a small ship, not suited to the task she undertook. There is no reason to be sceptical about the failure of aircraft and air navigation, when the advances made in the last few years are borne in mind. 'Aeroarctic' is looking well ahead in formulating its plans, and even if the full programme cannot be carried out for some years, the Society merits support in having devised the only scheme by which the scientific exploration of the inner Arctic regions seems to be at all possible.

In a few years there will occur the fiftieth anniversary of the year of international polar stations of 1882–83. Twelve States took part, each dispatching one or more expeditions to take a year's meteorological observations in high northern or southern latitudes. The jubilee year of that effort might suitably be celebrated by some similar international co-operation in high latitudes. On the other hand, it has been suggested that two permanent Antarctic observatories, in addition to the one already existing at the South Orkneys, and two additional ones in the Arctic, in Canada and Siberia respectively, might serve better the cause of meteorological and magnetic research. The adoption of either plan depends on the resources available and the foresight of the States concerned. It is impossible to promise definite practical results in weather forecasting from the foundation of such stations. All that can be said is that a more detailed knowledge of meteorology may entail results of practical value, and that without this knowledge such results cannot be forthcoming. 'Aeroarctic' makes no promise as to results. It is a purely scientific body, and in its efforts to establish polar observatories and further other lines of research it is moving in the right direction.

An Intimate View of Seventeenth Century Science.

The Correspondence of Spinoza. Translated and edited with Introduction and Annotations by Prof. A. Wolf. Pp. 502. (London: George Allen and Unwin, Ltd., 1928.) 15*s*. net.

THE thinkers of the seventeenth century took all knowledge for their provinces. The men of science were at the same time physicists, chemists, biologists, and geologists, might also be astronomers and architects; often, in addition, they showed deep interest in theological matters, although this interest was manifested in widely different ways, as witness the names of Boyle, Newton, and Leibniz. On the other hand, lawyers and philosophers took an active part in the scientific life which sprang into such activity in the second half of that century, ludicrous as might be the writings of a Matthew Hale on the vacuum, futile as might be the attacks of a Hobbes on the mathematical achievements of a Wallis. It was impossible for so bold and original a thinker as Spinoza not to take his part in the discussion of the new results that came pouring from the laboratories in a manner reminiscent of our own times, more especially as he was earning his living by grinding lenses. It is true that he made no original contribution to the scientific thought of the day, and likewise made no experimental discoveries. Nevertheless, from his letters we can form a lively picture of the days when the appearance of a "Certain excellent treatise on Sixty Observations with the Microscope" (Hooke's "Micrographia") was causing a sensation, and when Mr. Huygens was performing in London experiments confirming his hypothesis of impact; when Latin translations of the books of the very noble Mr. Boyle were eagerly awaited by continental writers unable to read English; and when "Hevelius of Dantzig and the Frenchman Auzout were disputing among themselves about the Observations which were made". The chief interest of the letters is undoubtedly for the philosophers who find therein discussed at length Spinoza's conception of God, but the man of science, as such, who has the faintest historic sense cannot but be entertained to find himself in a world where the transmutation of silver to gold witnessed by Helvetius was a matter of lively inquiry, and where the authority of Descartes was well-nigh absolute.

One of the chief figures in the correspondence of Spinoza is Henry Oldenburg, the secretary of the Royal Society, whom Hooke irascibly labelled as a "trafficker in intelligences". We find him communicating to Spinoza scraps of information about the work of Boyle (who, probably because Spinoza's religious views were so abhorrent to him, never wrote to him directly), in which Spinoza was keenly interested, and begging in return for "anything you may have learnt about the success of Huygens in the polishing of Telescopic Glasses", and in the same breath for political information: "Explain to me, if you can, what the Swede and the Brandenburger are driving at". However, as Prof. Wolf remarks in a note, Huygens' optical researches were carried out with such secrecy that Spinoza would not have learnt much about them even had he pushed his inquiries. He also seeks information on many metaphysical points, but, while praising Spinoza in the politest terms, seldom seems able to understand the replies. His mental parts stand out in these letters as clearly as his physical appearance does in the celebrated portrait at the Royal Society, and Hooke's contempt, if not altogether deserved, can be easily understood in view of the characters of the two men. A more celebrated figure in the correspondence is Leibniz, who in one letter sends Spinoza a "Note on Advanced Optics", saying that he will not easily find a better judge in this kind of study, which gives us a more favourable opinion of Spinoza's powers in this line than is furnished by the scraps of optical work found in Spinoza's own letters.

Great thinker as Spinoza was, his acuteness seems to have deserted him as soon as he meddled with experiment—a trait not unusual in philosophers. He describes one experiment, not particularly well contrived, which he made on the flow of liquids through a tube, and his conclusion from this was, in modern language, that liquids have no viscosity: "Therefore water running through a tube forty thousand feet long would after a short time, and solely through the pressure of the higher water, acquire as much velocity as if the tube were only one foot long", a result with which he is quite satisfied, although the fact that water stirred in a basin soon comes to rest might, on a little consideration, have led him to doubt his deduction.

Boyle, Huygens, Descartes, and Leibniz are the chief names of interest to the physicist which occur in the letters. Of Galileo there is nothing; Spinoza writes solely of his contemporaries. We cannot help regretting that his early death deprives us of any comment on Newton, whose "Principia" did not appear until ten years after Spinoza's death. It is nevertheless astonishing, and does little credit to Oldenburg's perspicacity, that Oldenburg has nothing to say of Newton, whose work on the colour of thin plates was communicated to the Royal Society long before the correspondence closes.

For the production of the book, and for Prof. Wolf's work as translator and editor, we have nothing but praise. We know of none else who combines technical philosophical skill with knowledge of the history and spirit of science in a sufficient degree to undertake successfully a task like this, which is beyond the scope of the specialised philosophy of the present day. We are furnished with an admirable introduction, comprising a sketch of the scientific background of the correspondence and biographical details of the chief personages concerned, some tolerably obscure; with comprehensive and illuminating notes, such as only a profound student of Spinoza and of the period could write, and an excellent index. What more could be demanded? E. N. DA C. A.

The Mysore Tribes and Castes.

The Mysore Tribes and Castes. By the late H. V. Nanjundayya and Rao Bahadur L. K. Ananthakrishna Iyer. (Published under the Auspices of the Mysore University, Mysore.) Vol. 2. Pp. vii + 559 + 80 plates. (Bangalore: Mysore Government Press, 1928.) 12.8 rupees; 20*s.*

IT is now nearly thirty years since the late Sir Herbert Risley initiated the systematic ethnographical survey of the larger Indian Provinces and certain native States. Much useful work has been produced on the lines then laid down for the work of the survey, notably the "Tribes and Castes of the Central Provinces", by the late Mr. Russell, who was fortunately able to complete his four volumes before he so tragically fell a victim to the War. We have here Vol. 2 (which seems to have preceded Vol. 1) of a similar work on the tribes and castes of Mysore, taking us from Agasas to Budbudkis in a volume of 559 pages. A similar range in the records of the Bombay ethnographical survey ("Tribes and Castes of Bombay", 1920–22. Enthoven) occupies only half this space, so that the Mysore records, before completion, threaten to fill many volumes.

If this volume has taken some time to produce, and the completion of the survey seems still somewhat remote, much credit must be allotted to the editors for the fullness of the materials and the care with which they have been handled. Tribal origins, endogamous and exogamous divisions, birth, marriage, and death customs are dealt with systematically. Perhaps a little more attention might have been given to the so-called exogamous sections which are the subdivisions of the tribe or caste inside of which marriage is not permissible, that is to say, a bride of one such section must find a bridegroom in another. In many cases these sections are totemistic, named after a tree, plant, or animal. In view of the importance which attaches to these survivals of totemism, which has attracted special attention in the adjacent Province of Bombay, somewhat fuller details of the *balis*, as they are called, would have been welcome.

We believe that the editors are correct in assuming the identity of Ramoshis and Bedars in their excellent article on that well-known tribe. The Bedars, after pressing north into the southern portion of the Bombay Presidency, appear to have acquired the Marathi language and to have been renamed Ramoshis. As a thieving community they are to this day allowed to live on a form of blackmail in the Deccan by being employed as night watchmen in private residences at a reasonable salary, equivalent to insurance against the attentions of their fellow tribesmen.

We find in the account of the fishing caste known as Bestas, the equivalents Toreya, Ambig, Kabber, and Gangamakkalu (that is, children of the Ganges). Other well-known synonyms are Kabbligar and Kabera. Here it may be observed that, unfortunately, the authors of this work have not adopted the practice of showing in separate entries all synonyms for caste and tribe names and for the names of their divisions. For a student not well versed in the subject such entries are invaluable. In their absence, he is quite unable to find a caste or tribe unless he knows the particular synonym under which the survey record shows it. One or two minor criticisms also seem called for. The quotations from the works of other writers, though apparently meant to be verbatim, are in places not quite accurate. Palegars are referred to indifferently as Palayagars and Paleyagars. The well-known author of the "Tribes and Castes of the Central Provinces" appears invariably as Russel. An interesting but surely quite irrelevant picture of the beautiful Gersoppa Falls is included in the illustrations. It is not obvious how such an addition to the work can help to throw light on the habits and customs of the tribes and castes of Mysore; and in such works some literary reticence is essential, if the dimensions are to be kept within reasonable limits.

These criticisms made, we should like to congratulate the remaining author warmly on the result of his efforts, as well as to deplore the loss of Mr. H. V. Nanjundayya. The writer of this notice was in close touch with Mr. Nanjundayya during the early days of the work in Mysore. It is to be regretted that this learned worker has not surviv ed to witness the publication in final form of his very valuable contribution to the study of Indian ethnography. R. E. E.

Infra-Red Spectra.

Infra-Red Analysis of Molecular Structure. By F. I. G. Rawlins and A. M. Taylor. (The Cambridge Series of Physical Chemistry.) Pp. xv + 176. (Cambridge: At the University Press, 1929.) 10*s.* 6*d.* net.

IN view of the numerous and important researches which have been carried out in the infra-red region of the spectrum, it might appear surprising that until now there should have been no book in English dealing exclusively with this branch of spectroscopy. The methods employed have been most ingenious and diverse, and the results will assuredly contribute as much to the solution of molecular problems as photographic spectroscopy has contributed to those of atomic structure. Yet the experimental difficulties have so greatly restricted work in this field that there has been little demand for a book of this kind. Now that the significance of such researches is being realised, whilst at the same time standard methods have been to some extent developed, it is most desirable that the knowledge which has been acquired with so much labour and difficulty should be made more easily accessible to the student and prospective worker in this field.

The four chapters of the work which is at present under notice deal successively with the infra-red spectra of gases, liquids, and solids, and with experimental methods. A really comprehensive or detailed treatment is naturally out of the question in a book of this size, but the authors have succeeded in compressing a quite remarkable amount of information into the limited space available. The mathematical appendix, in which, *inter alia*, a brief but unusually clear account is given of the application of wave mechanics to molecular vibration and rotation, is particularly to be commended. The list of references at the end of each chapter appears to have been compiled with discrimination, and is an extremely valuable feature.

The book is by no means a mere compilation. The authors themselves have worked extensively in these regions, and are therefore in a position to contribute useful criticisms and suggestions. They suggest, for example, the desirability of substituting direct readings of prism orientation for the drum and lever arrangement in common use. In several places they emphasise, and very rightly, the necessity of measurements of intensity of absorption as well as of spectral position. In very few cases indeed have workers derived coefficients of absorption from their observations, being mostly content to plot galvanometer deflections against wave-length, and for no single substance, so far as we are aware, is the absorption coefficient known over any considerable spectral range.

There are a few slips which should be rectified in future editions. In two cases (pp. 131, 144) the credit due to the actual research worker is attributed to the author of a book in which his results are quoted. On p. 138 it is implied that the diffraction breadth of a spectral line is determined by the width of the entrance slit of the spectrometer, and one's suspicions of the unorthodox nature of the authors' views on resolving power are strengthened by the statement (p. 115) that it is, "as usual, proportional to the numerical aperture of the mirror". The account of photographic methods in the infra-red is distinctly inadequate, having regard to the important developments of the last few years.

Finally, a protest may be lodged against the ugly and unnecessary term "many-lines" spectrum of hydrogen. It is, of course, a literal translation from the German, but the already established term "secondary spectrum" is much to be preferred. In view of recent progress, it would seem still better to refer to it as "the band spectrum of hydrogen", or simply as "the H_2 spectrum". The book is well indexed and reasonable in price, and should find favour with chemists and physicists alike.

Our Bookshelf.

An Etymological Dictionary of Chemistry and Mineralogy. By Dr. Dorothy Bailey and Dr. Kenneth C. Bailey. Pp. viii + 308. (London: Edward Arnold and Co., 1929.) 25*s.* net.

THE aim of this dictionary is primarily *etymological*, and no attempt at exhaustive definitions has been made. Apart from its literary interest, however, its utility is, as the authors suggest, definitely enhanced by the inclusion of references. These, in many cases original, indicate where more complete definitions and descriptions of many uncommon minerals and chemical compounds may be found. Approximately 11,000 words are listed in the dictionary. These include many scientific terms, in addition to substances, though the work is stated to be less complete with respect to terms than to names. The difficulty in finding a dividing line between chemistry and mineralogy caused the authors to include the latter science in a work originally intended to embrace only the former.

One point is well exemplified in this dictionary. This is the unfortunate and prevalent habit of naming minerals after places and people, without the slightest indication of chemical composition or physical properties. It is to be regretted that some form of nomenclature more akin to the usually rational and comparatively intelligible system applied to chemical substances has not been adopted for minerals.

Words current in the literature of the two sciences from the middle of the nineteenth century onwards are included, and the dictionary is sufficiently up-to-date to include names appearing in 1928. No important defects or omissions were noticed, and the work can be recommended as likely to prove a useful addition to scientific reference libraries. V. A. E.

Photometric Chemical Analysis (Colorimetry and Nephelometry). By Prof. John H. Yoe. With Contributions to Vol. 2 by Dr. Hans Kleinmann. Vol. 2: *Nephelometry.* Pp. xvi + 337. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1929.) 22*s.* 6*d.* net.

THE volume contains a history of the development of nephelometers, an account of the theory of nephelometry, and examples of the use of the nephelometer in inorganic and organic analysis; it has a useful bibliography and satisfactory author and subject indexes. Prof. Yoe rightly lays stress on the necessity of studying systematically every reaction producing turbidity that it is desired to use in nephelometric investigations, as to the stability of the suspension and the limits of concentration that may be employed, and of standardising each instrument with each suspension used. Some squared paper is interleaved in the volume, serving the useful purpose of supplying a convenient place for the preservation of necessary calibration curves of the nephelometer in use. A table of atomic weights later than 1925 is not included. The volume is to be welcomed as providing a comprehensive study of nephelometric methods and an outline of the technique for carrying out nephelometric research. A. G. F.

The Custom of Couvade. By Warren R. Dawson. (Publications of the University of Manchester, No. 194: Ethnological Series, No. 4.) Pp. ix + 118. (Manchester: Manchester University Press, 1929.) 7*s.* 6*d.* net.

THE strange custom of couvade, which consists of various taboos for and practices by the father of a new-born baby, more particularly his 'lying-in', has attracted the attention of many writers. Mr. Warren R. Dawson has evidently studied the subject to see how it would fit in with the migration of culture theory of Elliot Smith, but he can "merely throw out the suggestion that couvade *may* originally have been part of a religious ceremonial which was afterwards invested with new and varied significance and made a mere family concern. . . . We must, with Ploss, humbly admit that the state of our knowledge regarding the original motive of the couvade custom is expressed by a single word—*ignoramus.*" At all events, the author has done good service in bringing together a very large number of references and in clearing away some of the debris that has hitherto encumbered the discussion of couvade, and he has succeeded in his object of collecting into a convenient compass the material for a reconsideration of a puzzling and interesting problem.

A Text-Book of Pulmonary Tuberculosis: for Students. By R. C. Wingfield. Pp. xvi + 401. (London: Constable and Co., Ltd., 1929.) 31*s.* 6*d.* net.

THE treatment of phthisis, as Dr. Wingfield points out in his preface, has been so largely taken over by special hospitals that the medical student at a general hospital has little opportunity for studying the disease. A brief course of instruction at a special institution is essential, and to assist the student in taking full advantage of it, this text-book has been produced. It gives sufficient attention to detail without being too long and exhaustive for easy study. The subject of treatment naturally fills a large section of the book; the student and general practitioner tend too frequently to consider this a matter entirely for the specialist, and to neglect the fact that the mode of life prescribed and learned at the sanatorium has to be carried out later under the supervision of the family doctor. It is of interest to observe that treatment by gold compounds has not been so entirely abandoned as was once thought, and that sanocrysin does seem to have a limited sphere of usefulness. The book is very well illustrated by radiographs and temperature charts.

Animal Psychology for Biologists. By Dr. J. A. Bierens de Haan. Pp. 80. (London: University of London Press, Ltd., 1929.) 4*s.* 6*d.* net.

THIS little book consists of three lectures on certain features of the psychology of animals, excluding man. In the first, Dr. Bierens de Haan insists on the independence of animal psychology as a science, dissociating it from subsistence on the kindred sciences of physiology and human psychology. He defines as its aim the study of subjective phenomena in animals, from the highest to the lowest, and offers evidence that even the amœba experiences these phenomena. The animal is discussed as a knowing subject in the second lecture and as a feeling and striving individual in the third. Dr. Bierens de Haan evidently regards mental evolution in animals as having reached a level much more approximating to man's than is generally accepted. He considers that in higher animals there can be "an implicit understanding of the connexion of causes and effects", a psychological process equivalent to a primitive form of conceptual thought in man. Whether one agrees or not with his conclusions, they are a welcome stimulus to research in the many problems in this science still awaiting solution.

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 General Applicability of Fechner's Law in Colour Sensation.

HELMHOLTZ long ago remarked that, in the matter of sensation of light, we have to deal with quality as well as quantity. That is to say, in physical language, luminous sensation is a vector quantity; and, since experiment indicates that it is a vector quantity of three dimensions, tridimensional vectors are appropriate to its geometrical representation.

Without any reference whatsoever to a Cartesian scaffolding, we can represent two different luminous sensations by two vectors, α and β, say, and the quaternionic operator $\beta\alpha^{-1}$ is the active operator which transforms α into β. It must therefore contain in itself data for a specification of the changes of sensation which are present in the passage from the one sensation to the other. These may be expressed in various ways; for example, in terms of independent changes in the intensities of three fundamental sensations, or in terms of changes of intensity, hue, and saturation. But it is not possible to attain to any results apart from experimental guidance as to the laws which have to be satisfied.

Now there was available to Helmholtz, for the development of his idea, no experimental information beyond that expressed in Fechner's law, either in its simplest or in its more extended forms. Yet he used it, in its simplest form, very effectively, in the investigation of differential sensitivity throughout the spectrum. In its next simplest form, he used it, very effectively too, in the explanation of variation of colour with intensity. He also based upon the action of self light a more general expression for it, which, as applied to the observations of König and Brodhun, has been found by Clara O. T. M'Kenzie to give remarkable correspondence over the whole range of intensity from nearly dazzling magnitude to approximate invisibility. But, as no other fundamental law was known at the time, he was unable to proceed further in the direction of the discrimination of expressions for hue and saturation. "I have the feeling", he said, "that in equating luminosities of different colours, the question is not that of comparing one-fold magnitudes but two-fold magnitudes compounded of brightness and colour glow, for which I cannot give any simple summation, and which I cannot scientifically define further." Experiment was needed to give data for the discrimination. Abney's additive law for component brightnesses was not then formulated.

If we consider the colour vectors α and β, without making any specification of *how* intensities of sensation are involved in their tensors $T\alpha$ and $T\beta$, we can express the transforming factor, which, acting upon α, producing β, in the form

$$q = \beta\alpha^{-1} = \frac{T\beta}{T\alpha}(UV\alpha\beta)^{\frac{2\theta}{\pi}}.$$

Here, in the apt Hamiltonian notation, $UV\alpha\beta$ is a unit vector normal to the plane containing α and β, and θ is the angle between these vectors. We must regard the tensor factor in q as associated with intensity, and the versor factor as associated with colour quality. Now we can take the step which Helmholtz was unable to take, and determine another quaternion Q which will be directly expressive of the corresponding sensations. To satisfy the simple form of Fechner's law we may write

$$Q = \log q = \log \frac{T\beta}{T\alpha} + \log (UV\alpha\beta)^{\frac{2\theta}{\pi}},$$

where the first term on the right-hand side is a scalar quantity, while the second is a vector which only vanishes when $\theta = 0$. The latter must therefore in this case represent the change of colour sensation, and the former the change of the intensity sensation, as the light changes from the type α to the type β. But, if we adopt this expression, we must regard the intensities as being represented by the tensors; in which case the corresponding geometrical construction (Lambert's pyramid) would compel us to take the square of a resultant intensity as equal to the sum of the squares of the component intensities.

Now this is in direct opposition to Abney's law. But, before considering that point, we may find what, on this scheme, is the measure of the colour sensation change. We have

$$\log (UV\alpha\beta)^{\frac{2\theta}{\pi}} = \theta \, . \, UV\alpha\beta,$$

and so $\theta = TVQ$ directly measures the change in colour sensation. But, if we take the quaternion

$$Q' = 2 \log q = \log \left(\frac{T\beta}{T\alpha}\right)^2 + \log (UV\alpha\beta)^{\frac{4\theta}{\pi}},$$

in order to get Fechner's law we must regard the tensors as representing the square roots of the intensities—a condition which might perhaps have been guessed at since intensity (measurable as energy) is the square of the tensor of a vector. This geometrical construction seems to have been first used by W. Pauli, jun.; and it directly expresses Abney's law.

The vector term in Q' is $2\theta UV\alpha\beta$, which gives $TVQ' = 2\theta$ as the measure of the change in colour sensation. Schrödinger's representation, which gives this result, is therefore equivalent to the postulate that the sensation changes correspond directly to the components of the quaternionic operator which transforms the one colour vector in Pauli's space into the other: the change in the sensation of intensity being twice the logarithm of the scalar part of the operator, while the change in colour sensation is twice the logarithm of the versor part.

Thus Fechner's logarithmic law applies alike to intensity stimulus and to colour stimulus. Of course, experiment alone can settle whether the proportion is one of equality or not. It may be, for example, that we should take $Q' = 2 \log q + V \log q$, the first term alone being doubled. In that case the change of colour sensation would be measured by the angle between the vectors themselves and not by double that angle.

It is useful to express Q' otherwise. If γ be any unit vector, we have

$$Q' = \log \left(\frac{T\beta}{T\alpha}\right)^2 + \log \frac{(UV\beta\gamma)^{\frac{4\theta_2}{\pi}}}{(UV\alpha\gamma)^{\frac{4\theta_1}{\pi}}},$$

where θ_2 and θ_1 are respectively the angles between the vectors β and γ, α and γ. So

$$Q' = \log \left(\frac{T\beta}{T\alpha}\right)^2 + \log \left\{ \left(\frac{UV\beta\gamma}{UV\alpha\gamma}\right)^{\frac{4\theta_1}{\pi}} (UV\beta\gamma)^{\frac{4(\theta_2 - \theta_1)}{\pi}} \right\}$$

$$= \log \left(\frac{T\beta}{T\alpha}\right)^2 + \log \gamma^{\frac{2\psi}{\pi} \cdot \frac{4\theta_1}{\pi}} + \log (UV\beta\gamma)^{\frac{4(\theta_2 - \theta_1)}{\pi}}$$

$$= \log \left(\frac{T\beta}{T\alpha}\right)^2 + \psi \frac{4\theta_1}{\pi} . \gamma + 2(\theta_2 - \theta_1) UV\beta\gamma,$$

where ψ is the angle between the planes (β, γ) and (α, γ).

If γ be the white vector, the third term represents the change in the sensation of saturation as we pass from the colour vector α to the colour vector β; and the second term gives the corresponding change in the sensation of hue. It is evident from the form of the curve in Maxwell's triangle that, on this representation, the peculiar shape of Helmholtz's differential insensitivity curve arises in connexion with variation of hue.

The representation of Q' as a sum of three logarithms is an extension of Fechner's law for brightness.

W. PEDDIE.

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Dundee.

Parasitic Autotomy in Worms and its Possible Significance.

WHILE examining certain Enchytræid worms for the stages of two cœlomic gregarines having periods of infection at different times in the year, namely, spring and autumn respectively, I found that the cœlom quickly became free from cysts at the end of the life-cycle of each type.

During June and July of 1929 I kept six heavily infected worms in the laboratory for the purpose of allowing the parasites to attain a certain stage in development. In the first week in August four of these worms were removed for examination and the remaining two left in the soil. On examining the latter two weeks later (Aug. 24) I found that both had lost the posterior segments, while the cœlom of one was free from parasites and that of the other contained a single cyst only.

Autotomy caused by parasites has been described in Echinoderma and in Polychæta, and Hesse ("Contribution à l'étude des Monocystidées des Oligochètes", *Arch. Zool. Exp. et Gén.*, 1909, (5), III., p. 27 à 301) mentions it as a possible mode of dissemination of parasite spores from the cœlomic cavities of Oligochætes. Dr. Keilin (*Parasitology*, **17**, pp. 170-172; 1925) has observed parasitic autotomy to be one method of liberation of the spores of gregarines from the cœlom of such earthworms as *Allolobophora* and *Helodrilus*. In my specimens of Enchytræid worms, large phagocytic cysts such as Dr. Keilin describes are not formed, but the cysts of the gregarines do tend to mass together in the posterior region, and there they displace and press upon the intestine. I have seen heavily infected worms showing constriction of the body and have noted many instances of regeneration of the terminal segments, but until now have never obtained proof of the actual loss of this part of the body. Two results follow: first, the spores are shed into the soil, where they may be taken up by, and infect, other worms—a simple method of disseminating infection; and, secondly, the cœlom is cleared before the invasion by the other type of gregarine which enters it very soon after the cycle of the first is completed.

When the parasites are present in the head region, the cysts accumulate in the segments anterior to the reproductive organs. I have not had the opportunity of keeping such a specimen for any length of time, but have frequently observed very heavy infection in this region. Further, on several occasions I have found worms in which the head region was being regenerated, and have also seen two examples of a length of an Enchytræid worm regenerating both head and "tail". Perhaps parasitic autotomy occurs in the head region also?

MABEL FULLEGAR.

Natural History Department,
University College, Dundee, Oct. 24.

The Physical Identity of Enantiomers.

IT has always been stated that, apart from the sign of the rotation and the solubility of their salts with optically active bases or acids, the physical properties of dextro and lævo enantiomers are identical. In an investigation (*Jour. Chem. Soc.*, 1111; 1929) of certain physical properties of the liquid active and racemic esters of tartaric acid, it appeared that in the case of this series there is a great difference in the degree of association of the active and inactive forms. It is usual to attribute association to something of the nature of the 'a' factor of the van der Waals' equation, that is, to stray fields, free energy, etc., in the immediate neighbourhood of the molecule, and, when this action takes place between molecules of the same kind, it is thought to be physical rather than chemical in its nature. If, now, we suppose combination to have taken place between the dextro and lævo forms, energy will have been evolved, and the stray field reduced, with consequent decrease of the degree of association. This is the observed fact; the inactive form is less associated than the active.

In view of the above, and of the fact that the existence of racemic compounds in the solid state (in certain cases, at least) has never been doubted, it seems that chemical combination can take place between dextro and lævo forms, and that this action is different from that acting between molecules of the same form to produce association. Therefore, there must be a slight difference in chemical nature between the opposite active forms, since, if there were not, they would combine together to the same extent to which they combine (associate) with themselves. Finally, if there is a difference in chemical nature, there must also be a difference in physical properties. It has always been assumed that there is no difference, and, since the difference is no doubt slight between, for example, the freezing points of the dextro and lævo forms, it may very well have been overlooked or attributed to experimental error.

It is possible, however, to determine certain physical properties with very great accuracy, and an investigation directed, first towards the preparation of both active forms in a state of the highest purity, and, secondly, to the determination of such physical constants, for example, the freezing points, as are susceptible of very accurate determination, would perhaps yield results of great theoretical interest. In an investigation of this kind, the utmost care must be taken in purifying the materials, in drying thoroughly (and to the same extent in each case), etc. The freezing point, solubility, and specific rotation are properties which can be determined with great accuracy. I am investigating the physical constants of the esters, simple and substituted, of tartaric acid. In view, however, of the very great experimental difficulties involved in the preparation, and of the scepticism with which positive results may be received, it is very desirable that similar work on other series should be undertaken by other workers.

A. N. CAMPBELL.

Department of Chemistry,
University of Aberdeen.

Alternating Intensities in the Spectrum of Nitrogen.

THE rotational Raman bands excited by the $\lambda 2536$ mercury line in nitrogen and hydrogen show the alternating intensities characteristic of a symmetrical molecule with a nuclear spin. In my communications on the subject (NATURE, May 18, 1929; *Proc. Nat. Acad. Sci.*, **15**, 515; 1929) I reported the lines corresponding to transitions between even numbered rotational levels to be the strong ones in N_2, while the opposite is true for H_2.

In a recent letter to *Die Naturwissenschaften* (**34,** 673; 1929), Heitler and Herzberg pointed out that the result obtained on N_2 is rather surprising, as the symmetry of the electronic wave function in the normal state $^1\Sigma$ is the same in nitrogen as in hydrogen. This leads to the conclusion that the nitrogen nuclei satisfy the Bose-Einstein statistics, which appears in contrast with their structure consisting of seven electrons and fourteen protons.

In view of the importance of the problem, I have thought it worth while to check the experimental result with new measurements. The frequencies of the Raman lines had been determined by comparison with the spectrum of the iron arc. If a relative displacement between the Raman spectrum and the comparison spectrum had occurred (although every care had been taken to avoid this source of error) it would have been possible to mistake the even numbered rotational lines for the odd ones.

I have therefore made new measurements, taking only mercury lines in the spectrum of the scattered light for reference. In two plates, the exciting line $\lambda 2536$ is not too over-exposed, and a fairly accurate reading of its position is possible. This enables one to distinguish the even and odd numbered lines without further reference. Moreover, the sharp mercury line $\lambda 2534 \cdot 77$, $\nu 39439 \cdot 8$, provides a good standard, and appears to coincide very accurately with a strong line of the Raman spectrum. This affords another independent method of deciding the question.

Accurate measurements made with the two different methods and by independent observers have confirmed the former result. The measured frequencies of the strong lines usually agree with those calculated on the assumption of even quantum numbers within one frequency unit, whilst a systematic error of eight frequency units would be necessary to cause a misinterpretation.

I may remark here that, in the case of oxygen, the electronic wave function of the normal $^3\Sigma$ state is antisymmetrical, because, according to Mulliken (*Phys. Rev.*, **32,** 186; 1929), the structure consists, in addition to closed shells, of two electrons in $3p\pi$ states, which have parallel spins and can be shown to give an antisymmetrical contribution. As only the odd-numbered rotational levels are present, it follows that the oxygen nuclei satisfy the Bose-Einstein statistics. This is what we should expect of a structure of sixteen protons and eight electrons.

F. RASETTI.

Physical Laboratory of the Royal University,
Rome, Oct. 20.

Monœcious Oysters.

IN NATURE of June 8, Ikusaku Amemiya gives a list of five species of oysters recorded as being monœcious, and later, July 6, Paul Pelseneer adds two additional species, making a total of seven altogether. The only monœcious species in this list recorded from Australasian waters is *Ostrea angasi* (the correct name has now been determined as *O. sinuata* Lamarck). After a careful examination of large numbers of oysters from the South Island of New Zealand, and also of the oysters which have been introduced from there into the Derwent River in Tasmania, I have come to the conclusion that the New Zealand oyster is specifically distinct from *O. angasi*. Hutton's name, *O. lutaria*, will therefore stand, and this species is larviparous and hermaphrodite.

Then, too, during a recent investigation of the oyster resources of Queensland I chanced across an unidentified species carrying larvæ in the mantle cavity. *O. lutaria* and this unidentified species must be added to the list of recorded hermaphrodite oysters.

Every species in this list appears to be of the larviparous type, but the commercial oyster of New South Wales and Queensland (*O. cucullata*), although oviparous, was shown by me to undergo a sex-change (NATURE, Sept. 29, 1928).

The list of monœcious oysters will therefore now embrace *O. edulis, O. sinuata* (=*angasi*), *O. lurida, O. denselamellosa, O. plicata, O. equestris*, an undeterminable species from Saleh Bay (Sumbawa), and *O. lutaria, O. cucullata*, and an undetermined species from the Queensland coast, making ten in all.

T. C. ROUGHLEY
(Economic Zoologist).

Technological Museum,
Sydney,
New South Wales.

Vibrating Air Column of High Frequency.

IN the course of some experiments recently carried out in these laboratories, a curious series of annular markings was observed in a glass tube through which air, carrying water-vapour and powered charcoal, was passing under diminished pressure. The accompanying photograph (Fig. 1) shows the regularity of

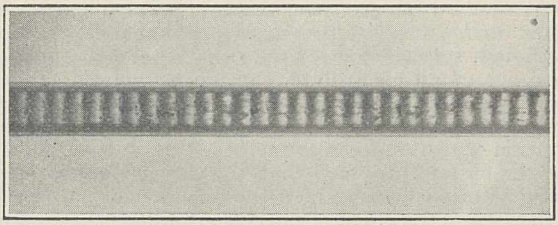

FIG. 1.

the distribution of the rings, of which 48 occupied a length of one decimetre. The diameter of the tube was 4·5 mm., and the pressure at the time of the experiment was approximately 600 mm. of mercury.

It is tentatively suggested that the phenomenon is due to supersonic vibration possibly originating at the narrow inlet and thence communicated to the air column. On this assumption a frequency of about 150,000 vibrations per second would be indicated. So far as we are aware, this figure is the highest yet recorded.

S. K. CREWS.
F. C. HYMAS.

The British Drug Houses, Ltd.,
Graham St., City Rd., N.1,
Nov. 5.

Balloons for Upper Air Work.

SINCE 1926, balloons made of 'Vulpro' rubber tissue, manufactured by the Vultex Products, Ltd., London, have been made use of in the India Meteorological Department with gradually increasing success. These balloons are made at the Upper Air Observatory, Agra, more or less after the method described by Mr. J. H. Field in the *Memoirs of the India Meteorological Department*, vol. 24, pt. 5. Considerable difficulty was at first experienced in joining the tissue, but after extensive trials it was found that satisfactory joints could be made without difficulty by ordinary Dunlop rubber solution diluted with carbon tetrachloride.

The rubber balloons imported for pilot and sounding balloon work have been found to deteriorate very rapidly in India in spite of storage in the cold; and the adoption of 'Vulpro' tissue has been of great advantage for the development of upper air work in India. No special storage seems necessary, and the tissue, even a year after its manufacture, seems scarcely to deteriorate in quality. The percentage of premature bursts in case of the 'Vulpro' rubber balloons is almost negligible; hence they have been of immense service for ascents where risk of failure cannot be taken.

As an illustration of their performance, it may be mentioned that balloons $2\frac{1}{2}$ ft. in diameter made of tissue 0·004 in. thick and weighing about 150 gm. have taken Dines's meteorographs with accessories weighing 110 gm. up to a height of 20 km.

G. Chatterjee.

Upper Air Observatory,
Agra, India,
Oct. 24.

Electric Charge in its Relation to Complement Fixation.

Although the effect of specific immune serum, in the presence of a suitable electrolyte, in reducing the charge carried by bacteria has been thoroughly investigated, no work has been done on the relation of electric charge to complement fixation.

We have been studying this and other allied problems during the last two years and have shown that although sensitisation of red cells takes place in the absence of an electrolyte, specific hæmolysis cannot occur unless the charge of the red cells is reduced. For this an electrolyte is essential, and the concentration which is necessary depends upon the valency of the cation, provided that the salt in question has no deleterious action upon the complement. On the other hand, the effect of polyvalent anions is to maintain the high negative charge carried by the red cells, in which case hæmolysis does not occur.

We have shown that complement, considered as an entity, is negatively charged, and we are of opinion that the nature of the charge carried by the various components is one of the most important factors in the process of complement fixation and certain other immunological reactions.

We propose to deal with the matter more fully in the next number of the *British Journal of Experimental Pathology*.

H. C. Brown.
J. C. Broom.

Wellcome Bureau of Scientific Research,
33 Gordon Street, London, W.C.1,
Oct. 25.

The Second Spark Spectrum of Lead.

The second spark spectrum of lead was recently analysed by K. R. Rao and ourselves; and a preliminary report of the series regularities discovered was published in a paper (*Ind. J. Phy.*, vol. 2, pt. 4, pp. 468-476.) We have since become aware of a similar publication by Smith (*Proc. N. A. S.*, vol. 14, pp. 878-880; 1928). There is a good agreement between our results and those of Smith, except in the identification of $1\,^3P - 1\,^3S$. Evidently he has our $1\,^3S_1$ as his $1\,^3\bar{P}_1$. Carrol has very irregular intensities for the lines suggested by him. The $1\,^3S_1$ suggested by us is supported by the location of the second series $1\,^3S - 2\,^3P$, $1\,^3D - 2\,^3P$, and $2\,^3P - 2\,^3S$. Furthermore, $1\,^3P - 1\,^3S$ suggested by us is given additional support by the closeness with which it follows the irregular doublet law, for the isoelectronic sequences, Hg I, Tl II, and Pb III. An interchange of his levels $1\,^3S_1$ and $1\,^3\bar{P}_1$ would probably bring the whole scheme into alinement with ours. As a result of our attempts to get further regularities, we have been able to get $2\,^3P - 2\,^3D$ and $2\,^3P - 2\,^3\bar{P}$ as well.

At the time of publication of the above paper, not much progress had been made in the identification of the singlet spectrum. Attempts have since been made to identify this, and all the important lines arising from combinations between the singlet terms and intercombinations between the singlet and triplet terms have also been identified.

A. S. Rao.
A. L. Narayan.

Kodaikanal Observatory,
August 1929.

Subjective Demonstration of the Existence of the Muscular Sense.

When lying at full length in a bath of water, preferably salt, it is easy to demonstrate to oneself rather strikingly the existence of the muscular sense.

Allow one of the arms to float on the surface which, as is well known, it will do quite easily. When it has come to rest there, make an effort to raise it stretched out from the shoulder-joint. This, if done slowly and with all due attention to it, will appear to require considerable effort. Let the arm once more come to rest, and now proceed to submerge it; again the effort required will be very evident in consciousness.

If similar observations are made with the leg, the sense of effort needed to raise it and submerge it is again strikingly brought out. This purely subjective demonstration of the muscular sense may be recommended as a method of experiencing muscular sensations without the use of the more or less elaborate apparatus of the psycho-physical laboratory.

D. F. Fraser-Harris.

Chiswick, W.4,
Oct. 21.

Amphibious Centipedes.

Among the Research Items in Nature of Aug. 3, p. 209, the occurrence of marine centipedes is noted in Madras, other records being the Mediterranean, Atlantic coasts of Europe, and the shores of the Gulf of Mexico.

After a considerable experience of shore collecting, I can add the Cape Verde Islands in 1904, and the Galapagos in 1924. In the former case the centipedes inhabit crevices in the crust of *Melobesia* and *Vermetus* tubes, which covers all rocks at low tide inside bays, as described in the *Proc. Zool. Soc.*, p. 170, 1905; in the second case, large empty barnacle shells, also at low tide level and surrounded by a purely marine fauna. Marine spiders, which I had never seen since I obtained one in Zanzibar, among coral, in 1901, were found here also. The last was described in the *Proc. Zool. Soc.* about 1902, but the other three remain unexamined in the Cambridge and British Museums.

Cyril Crossland.

Pa'ea, Tahiti,
Oct. 4.

Medical Research: The Tree and the Fruit.[1]

By Sir WALTER MORLEY FLETCHER, C.B., K.B.E., F.R.S.

UP to quite modern days, the physician followed the strict Hippocratic tradition of concentrating his powers upon the welfare of the individual patient. He relied greatly, if not chiefly, upon rest in bed and upon the *vis medicatrix naturae.* He gave drugs for the palliation of symptoms, but had few, if any, weapons for attempting the specific cure of disease. His art, an art highly developed and refined, almost expended itself upon diagnosing accurately the exact process and the end result of the disease. I am not forgetting, of course, the exercise of his skilled functions in the right management of the patient's state of mind and in giving sympathetic and practical help to his friends—functions which in the physician's art at its best have always invested his office with a high nobility. But through the past generation, it has been his medical and non-medical colleagues in the scientific laboratory who have been putting into the physician's hands new weapons of precision, in the forging of which he has played little part himself and the mode of action of which he has to take largely upon trust.

The new sciences of organic chemistry and pharmacology have been yielding many new drugs artificially built up in the laboratory, that have specific and measurable actions upon particular microbes causing disease. Of these, salvarsan may stand as a type. Chemistry and pharmacology together have also given a new meaning to some of the oldest drugs that after immemorial use by native tribes have been prescribed by physicians for many generations. The infusions of the ipecacuanha root have long been used for the treatment of dysentery. Bacteriology has shown that dysentery is of two quite different kinds which earlier medicine had treated as one. One kind is due to infection by a particular group of bacteria; the other kind is due to organisms like the amœbæ belonging to the class of protozoa. Workers in India showed that it was the alkaloidal constituent of ipecacuanha which had this curative action, and later that this constituent, emetine, had its specific action only upon the amœbæ of dysentery and not at all upon the bacterial dysenteries. This specific action has been lately studied by new methods in the National Institute for Medical Research, and the path is open for an advance towards new and still better remedies for amœbic dysentery.

Cinchona bark, again, has been used as a remedy for malaria in Europe for two or three centuries. Of its various alkaloids, quinine was early isolated, and the physician concentrated upon this without any evidence that it was superior in its anti-malarial action to the other alkaloids present in the bark that were thrown away when commercial practice attended only to the quinine. This arbitrary choice of one constituent, although we now know that other cinchona alkaloids have effective anti-malarial actions, dictated the policy of selecting the species of the cinchona tree which yielded most quinine, irrespective of other important considerations, with the result that the world-price of the remedy practically available in commerce was kept disastrously high. In quite recent years the properties of the other alkaloids have been more thoroughly studied, and now the chemical laboratory has already produced a synthetic compound the action of which approximates to that of cinchona bark and gives hope that an effective and cheap specific may finally take its place.

Besides the specific remedies of this kind now provided as weapons of more precision for the physician, another important group of remedies has come into his hands. These are the so-called hormones—substances naturally produced within the body for the chemical control of particular functions. Knowledge of these is the result of the steady development during a whole generation of this branch of physiology, and British workers have played an active and most distinguished part in it. Some of these hormone bodies, for example, adrenalin, which controls the activity of the muscular coats of the blood vessels, intestines, and other organs supplied by the sympathetic nervous system, have a known chemical composition and can be made artificially. Most of them can only be prepared by extraction from the appropriate organs and have a molecular construction so large that it has not yet been chemically described. One of the most familiar of these, the active principle of the thyroid gland which the physician uses to remedy inborn or accidental deficiency, has lately been isolated and chemically described in London, and to this brilliant achievement, long the ambition of workers in other countries, has been added that of artificially constructing the molecule and so of synthesising the active principle 'thyroxin'.

Much has been heard lately of insulin, now used for the treatment of diabetes. This is a chemical substance of composition still unknown that is naturally produced within the body to control the use and disposition of the sugar-like substances derived from food which, roughly speaking, are concerned in the combustion processes supplying energy. A child or adult with inborn or incidental deficiency of insulin suffers from diabetes. He sinks into ill-health, kept at bay only by rigorous discipline, and he is faced by the prospect of increasing distress and an early death. These sufferers become as by magic normal and healthy persons if insulin is given to them from outside, and they remain normal so long as it is given. Those who would wish to belittle any result derived from animal experiments, even when the result derived is so great a work of mercy as this, are fond of asserting that insulin does not cure the disease. It is true that it does not remove the

[1] Abridged from the fifth annual Norman Lockyer Lecture of the British Science Guild, delivered on Nov. 19.

underlying cause of the deficiency, but it makes good the deficiency itself. It brings comfort and normal life to the diabetic sufferer for so long as its supply is maintained, just exactly as food brings comfort and life to a starving man, and for so long as it continues to be given.

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It amounts to a truism to say that progress in the practical arts of medicine in any of its branches, whether preventive or curative, only comes from the growth of accurate knowledge as it accumulates in the laboratories and studies of the various sciences. We find it a law of our state of being that, where only observation can be made, the growth of knowledge creeps; where experiment can be made knowledge leaps forward. The observation and description of diseases by physicians over many centuries have led to almost imperceptible advance. The experimental method, only fully and widely applied in the last generation or two, has given more progress in each decade than all earlier recorded history.

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Mankind naturally will always be eager for practical progress in medical work. Every layman now knows something of the many recent triumphs in medical science, but he knows also that these are isolated and incomplete. He sees clearly that, rapid as our progress has been within a period of years, amazingly short when compared with the preceding centuries, we are not in sight yet of anything like a victory over disease all along the line. It is a commonplace to complain that a common cold can be neither prevented nor cured. Every human child obtains its first lesson about the state of medicine by discovering that, as each infectious disease comes in its turn, the doctor has no magic beyond that of giving rest and warmth in bed. The general case-mortality rate for grave infections like those of pneumonia or puerperal fever has remained almost stationary for many years. The cause of acute rheumatism in children with its pitiful tale of subsequent heart disease is still unknown to us.

Every schoolboy knows the romance of the discoveries of the causation of malaria and its mode of transmission; he has learned in his geography lesson of the triumphant control of malaria and yellow fever that allowed the construction of the Panama Canal. But even in this region of tropical disease the layman sees that something is wrong and that our present knowledge does not allow us to press forward to final success. Yellow fever is still entrenched in West Africa, where it broods as a continual menace to the rest of the tropical world, its potential dangers being greatly increased by the modern possibilities of rapid transport. As to malaria, we have to admit that there are probably more rather than fewer sufferers in the world as a whole, though more than thirty years have passed since Ross under Manson's direction proved its insect transmission. We know enough to free a limited area from the disease if enough money be spent. Much more knowledge is required before we can hope for wider success in a general campaign. A hundred million sufferers in India alone must wait for relief until some generations of betterment have been traversed or until some increase in our knowledge brings, as we have every right to hope, some new kind of power.

To rest satisfied with our present achievements would indeed be a counsel of despair, and nothing could be more foolish or inhuman. Though our failures and deficiencies may be great, yet the successes already gained in the last few years, which are but as a brief moment in the history of man, should give us boundless confidence. Only the growth of scientific knowledge can bring success, and every victory must wait, as we know, upon the efforts of the unseen army of scientific workers. Practical statesmanship will turn at once to consider how that army can be aided and how it can be augmented. Let me quote Bacon again from his "Advancement of Learning". Three centuries ago he wrote: "If you will have a Tree bear more fruit than it has used to do, it is not anything that you can do to the boughs, but it is the stirring of the earth and putting new mould about the roots, that must work it". To turn this advice of his into practical effort to-day, we must consider in respect of our scientific army the primary questions of recruitment, of pay and of status, and I will take those points in turn.

As to recruitment, it can only be in the universities that the ablest young brains will be caught for the service. While it is true, indeed because it is true, that as Burke said, "the State is a partnership in all science, a partnership in all art, a partnership in every virtue and in all perfection", that Government will always be wise that makes the universities strong and leaves them free.

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If the service of research workers is to be recruited and maintained, questions of pay and status must have paramount importance. So lately as until just before the War, it was the almost universal rule in Great Britain that nobody should be paid for doing research work as such. Unless a man had private means, he could only keep himself at research work by being paid to do something else which very commonly conflicted with it. Much of it has always been done, of course, by university professors and other teachers heavily burdened with routine official duties. Salaries in academic life are in general indefensibly low. Even now professors who may be most eminent men of world-wide reputations, are fortunate if they receive £1200 a year, which was the low normal standard fixed by the recent Royal Commission for Oxford and Cambridge, and only a few with special administrative responsibilities receive £1500. These are salaries which men reaching eminent success in any other walk of life would regard as an offence, and even in the academic world the headmaster of a great public school would think of them derisively. In the junior university posts the salaries are relatively even lower. A man of distinguished ability, whether in teaching or research, may count himself lucky if after an expensive training and years of toil he earns £500 a year before he reaches thirty years of age. It is true that since the War the nation has greatly increased the resources of the universities by direct grants made through the University Grants Committee, and indirectly by the funds made available for the several departments responsible for promoting research work in the three fields of agriculture, medicine, and industry respectively. Those bodies have done much to remove the discredit of starvation wages for scientific men, but it is obvious that they cannot do more than lead the way in the right direction and not so rapidly as to bring dislocation to the university systems.

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Not only fairness, but also enlightened self-interest should provoke any nation to bring the pay of competent research workers to such a level that they may hope in middle life at least to be able to bring an education as good as their own within the reach of their children. Until that is done, we are in practice ensuring the sterility of those who, almost by definition, must be counted as amongst the most desirable begetters of our future stock.

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The community has been turning more and more eagerly for fruits ripe for its own service from the tree to the development and nurture of which it has given such small care. We have been calling for the better cure of our own sicknesses and better health for our great industrial populations. Now this call is being reinforced by another, by a call for the scientific help for which the development of our Empire overseas has been waiting and upon which it is dependent at every point. There can be no right government of any part of our Empire and no true advance in the industries and welfare of the peoples within it except in the light of truth, truth in the fundamental matters of human life, of animal and vegetable life, and in the less primary but indispensable affairs of industry. No secure progress can be made save under the guidance of those who have knowledge of the realities of Nature and of the methods by which that knowledge has been gained and can alone be extended.

This lesson is at long last beginning to be painfully learned, and already the governments, both central and local, are seeking for men competent at first hand in the methods of biological and other sciences. They are seeking most urgently of all for men competent to investigate and to remove the primary disabilities opposed to all industrial development by causes of human disease or ill-health and by the diseases of the animals and the crops on which man's life depends. But they have been confronted at once with a plain dearth of competent and available men, whether in the fields of medicine or of agriculture; and so much so indeed that official representations have been made by the Government to the British universities upon the need for an increase in the supply of able men trained in the biological sciences and competent to advise them. I believe firmly that not only the development of the backward parts of the Empire but also the very maintenance of the Empire itself in its present political form depends upon the satisfaction, and the early satisfaction, of that demand.

Our schools and universities are filled to overflowing with eager and daring youth, and our race has never failed to produce minds apt for original enterprise and discovery. Why is there this shortage of men, therefore, for work that brings the finest intellectual exercise and that gives immeasurable opportunities for service to the State in its need and to mankind at large and for ever? I think the reasons are plain, and they are well understood and have long been declared by the British Science Guild. They are reasons found in national habit and reasons found in details of present method. Our long-standing national habit, derived chiefly from the non-Grecian narrowness of centuries of unbalanced classical education—a narrowness which has hitherto denied the application of scientific method even to the technique of linguistic teaching itself—has fostered a distrust, or at best an ignorance, of the study of natural causes and of the power that it brings. Our statesmen hitherto have not been bred to trust in scientific method and to call upon it for aid. The families with the best resources, and so with the greatest responsibilities for leadership, have not in general thought it natural or even quite respectable for their sons to turn from the old traditional employments to the new avenues of public service in science to be found, for example, in medical or agricultural research.

. . . .

I have tried to bring to your minds a conception of the organic growth, with its ramifications, of a tree of knowledge making the whole body of known biological truth. I have spoken of the largely unseen body of men upon whose efforts its growth depends. Mankind, helpless otherwise, has gained new powers over suffering and fuller life already from the fruits of this growing knowledge and waits anxiously for new powers again that may add to those boons. If we look at the brief period in which our present knowledge has grown, a period making an almost imperceptible point of time in the immense ages still stretching before mankind on the globe, we are encouraged to look confidently forward to a long vista of scientific progress that will bring powers of control over the processes of life, of which we can scarcely at present conceive. They will bring with them resultant changes in human society in a thousand ways now almost unimaginable. The value to the community of a body of men and women working to gain that new knowledge upon which the possibilities of greater happiness and works of greater mercy will spring is great. But it is not to be measured in terms only of those material fruits. The moral health of the whole community must gain from the presence within it of a band of workers whose business it is to seek out the truth and whose work from its nature can only go forward in strict obedience to the truth and by means of its pursuit and expression without fear and without favour. As the Dean of St. Paul's has lately said, in the scientific life " a keen mountain air " is breathed, and something of the tonic air of this must always serve to brace and to elevate the general community.

The true worker in natural science can owe no allegiance to any tradition however venerable, or to any master however beloved. In his work he can only serve and express the truth, and for him the truth is that which can be tested by the touchstone of an appeal to Nature. He must forswear any selfish or sectional allegiance : he is " nullius addictus iurare in verba magistri ", and that phrase of Horace has become in shortened form the familiar and honourable motto of the Royal Society. If we attempt to measure the value of the scientific life within the community, we must put in the first place not the material fruits that spring from it, but the service it does to our reverence for truth and for the beauty it portrays.

The Royal Research Ship *Discovery II.*

THE launch of a ship specially built for oceanographic research is an event sufficiently rare to merit some notice in these columns. She is intended for the work of the Discovery Committee, and is for service in the South Atlantic and Antarctic, where she will be employed in biological and hydrological investigations concerned mainly with whaling. She was designed by Messrs. Flannery, Baggallay, and Johnson, consulting naval architects to the Committee, and was built to the order of the Crown Agents for the Colonies by Messrs. Ferguson Bros. of Port Glasgow. She was launched on Nov. 2 by Mrs. J. O. Borley and has been named *Discovery II.* The title ' Royal Research Ship ' has been approved by H.M. the King.

The R.R.S. *Discovery II.* has an overall length of 232 ft., a beam of 36 ft., a moulded depth of 20 ft., and a draught of 16 ft. when fully loaded. She is built of steel, and in several structural features is specially designed for ice navigation. Her stem is cut away at the fore foot and is rabbeted to protect the edges of the plates from chafing. The shell plating is doubled in the bow and at the water line throughout her length, while in the fore part the frames are closely spaced and transverse beams fitted in order to resist ice pressure. She is driven by a single propeller and reciprocating engines and on her steam trials developed a speed of 13½ knots. Her furnaces burn oil fuel, and the bunker capacity is sufficient to enable her to steam 7800 miles at full speed and more than 10,000 miles at economic speed.

The general arrangement is sufficiently shown in the illustration opposite. The wardroom is on the boat deck, with the chart room, a survey office, and the captain's accommodation above it. On the flying bridge there is a wireless direction finder and an indicating anemometer, both reading in the chart room. The wireless room is equipped for both long and short wave-lengths and is at the after end of the boat deck. Abaft it is the sick bay, which is provided with an X-ray apparatus. The main accommodation is on the lower deck, the petty officers being berthed aft.

The equipment for sounding comprises a Kelvin machine on the bridge deck, a Lucas deep-sea machine on the forecastle head, and both shallow and deep water echo-sounding apparatus of the latest Admiralty pattern. Bottom sampling instruments of various kinds will be carried, including two patterns designed to bring up cores of ooze in glass tubes.

For hydrological work and for vertical plankton nets three small winches are installed. Those on the forecastle head and abaft the engine room each carry 3500 fathoms of wire for deep-water observations. The third winch, placed on the well deck, has two drums of 500 fathoms capacity. These winches are used in conjunction with special davits, fitted with accumulators and recording sheaves and with electric lights for work at night. The hydrological instruments include a full equipment of water bottles of both insulating and reversing patterns, the Lumby surface sampler, the Merz-Ekman current meter, and two Carruthers current meters.

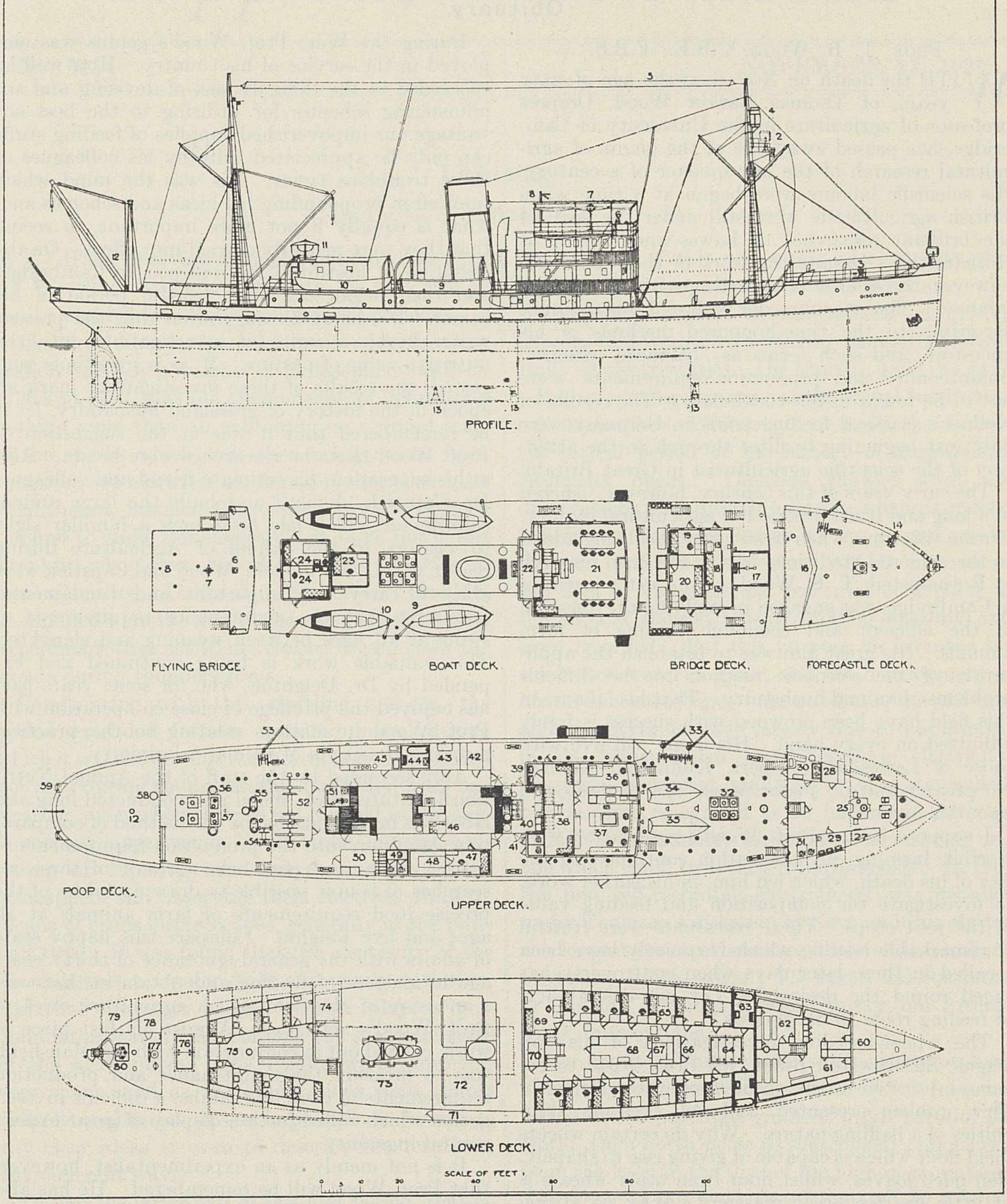
The main winch is placed abaft the engine room ; it carries two drums of wire rope, one 1000 fathoms, and one 5000 fathoms in length. The wire is led outboard by way of pedestal and stern fairleads, two of the former (one on either side of the ship) being fitted with recording dials to indicate the amount of wire paid out. A derrick is fitted on the poop deck for lifting heavy gear. The biological apparatus includes plankton nets of all sizes up to 4½ m. in diameter of opening, the continuous plankton recorder designed by Prof. A. C. Hardy, traps, dredges, and 40 ft. otter trawls. Closing mechanisms and depth gauges are provided for use with the plankton nets and a Watts current meter for registering slow speeds in towing.

The internal accommodation for scientific work includes spacious biological and chemical laboratories on the upper deck, both lighted by square windows. The former has a large gimbal table, special arrangements for supplies of preserving fluids and racks for reagents and specimen jars. The latter is fully equipped for chemical analysis of water samples, and includes also a distance thermograph, giving a continuous record of sea temperature, a chart-tracing table lit from below, and the large oceanographic slide rule recently designed by Dr. Sund.

Immediately below the laboratories, and communicating with them by means of a service lift, is a laboratory workroom with a bench, tools, and other fittings. In this room is a large vertical camera with special lighting for the photography of marine organisms, and the dark room is at the forward end. Farther aft, in the accommodation on either side of the engine room casing, are an instrument room, a laboratory for rough work in which an electric centrifuge is fitted, and a store room for plankton nets.

The ship carries 15 officers (including a scientific staff of 6) and 35 petty officers and men. She is expected to sail from London about Dec. 14, and will be under the scientific leadership of Dr. S. Kemp, with Commander W. M. Carey, R.N. (retd.), in executive command.

Royal Research Ship "Discovery II".



1. Searchlight.
2. Alternative position for searchlight.
3. Capstan.
4. Crow's-nest.
5. Wireless aerial.
6. Standard compass.
7. Direction finder.
8. Semaphore.
9. Life boat.
10. Whaler.
11. Motor boat.
12. Derrick.
13. Echo sounding apparatus.
14. Lucas sounding machine.
15. Deep water hydrological machine and davit.
16. Breakwater.
17. Steering-house shelter.
18. Chart room.
19. Survey office.
20. Captain's cabin.
21. Wardroom.
22. Pantry.
23. Wireless office.
24. Sick bay.
25. Windlass.
26. Carpenter's bench.
27. Boatswain's store.
28. Drying room.
29. Crew's wash-house.
30. Crew's galley.
31. Crew's W.C.
32. Skylight to officers' accommodation.
33. Shallow water hydrological and plankton machines and davits.
34. Pram.
35. Dinghy.
36. Chemical laboratory.
37. Biological laboratory.
38. Lobby.
39. Lavatory.
40. Officers' galley.
41. Officers' W.C.'s.
42. Boot and oilskin drying room.
43. Instrument room.
44. Petty officers' bathroom.
45. Rough laboratory.
46. Fire extinguishing apparatus.
47. Office.
48. Canteen store.
49. Petty officers' W.C.
50. Plankton net store.
51. Refrigerating engine.
52. Winch house and winch.
53. Deep water plankton machine and davit.
54. Auxiliary winch drum.
55. Pedestal fairlead.
56. Recording fairlead.
57. Skylight to petty officers' accommodation.
58. Torpedo hatch to steering engine.
59. Stern fairleads.
60. Chain locker.
61. Seamen's mess.
62. Stokers' mess.
63. Officers' bathroom.
64. Hatch to forehold.
65. Officer's cabin.
66. Linen locker.
67. Dark room.
68. Laboratory workroom.
69. Cabin of Director of Research.
70. Steward's store.
71. Communicating alleyway.
72. Boiler.
73. Engine room.
74. Refrigerating chamber.
75. Petty officers' accommodation.
76. Hatch to after hold.
77. Hand steering wheel.
78. Lamp room.
79. Vegetable locker.
80. Telemotor steering engine.

Obituary.

Prof. T. B. Wood, C.B.E., F.R.S.

With the death on Nov. 6, at the age of sixty years, of Thomas Barlow Wood, Drapers professor of agriculture in the University of Cambridge, has passed away one of the giants of agricultural research of the last quarter of a century. His scientific labours were begun at a time when British agriculturists were still under the spell of the brilliant researches of Lawes and Gilbert at Rothamsted. Despite the work of these pioneers, however, the science of animal nutrition was in its infancy. The stockbreeder still fed his animals according to the time-honoured methods of his ancestors, and such terms as 'balanced rations', 'maintenance' and 'production requirements', were not to be found in his vocabulary. The results of Kellner's classical feeding trials in Germany were only just beginning to filter through to the attention of the scientific agriculturist in Great Britain.

The early years of this century, however, ushered in a long and fruitful period of agricultural inquiry. During this time, when fresh lustre was being added to the splendid traditions of soil and crop research at Rothamsted, T. B. Wood, at the sister institute in Cambridge, was engaged in studying the question of the efficient and economic feeding of farm animals. His great aim was to establish the application of the scientific method to the difficult problems of animal husbandry. That his labours in this field have been crowned with success is freely admitted on every hand. His name will live with those of Lawes and Gilbert, Kühn and Kellner. No greater and no juster praise can be bestowed upon his memory.

I suppose it was Prof. Wood's association with Norfolk farming, an association continued to the day of his death, which led him, in his earlier work, to investigate the composition and feeding value of the root crops. These researches were fruitful of remarkable results, which frequently have been recalled in these later days when controversy has raged round the desirability, or non-desirability, of feeding roots to dairy cows.

The wheat-breeding investigations of his colleague, Sir Rowland Biffen, led Prof. Wood to become interested in the problem of wheat strength. This problem presented, and still presents, difficulties of a baffling nature. Why do certain wheats yield flour which is capable of giving rise to shapely, well-piled loaves, whilst flour from other wheats is of little use for bread-making ? Why do strong flours contain a tough, elastic gluten, whilst weak flours are characterised by a gluten of crumbly, putty-like consistency ? No fixed answer has yet been given to these questions, despite mass attacks on the problem in recent years. It was Prof. Wood, however, who, by dint of ingenious experiments, first shed light into the dark recesses of this strange and perplexing phenomenon. His two long papers published in the *Journal of Agricultural Science* for 1907 still remain classics, and no treatise on the subject of wheat strength is complete without a full consideration of the conclusions he arrived at.

During the War, Prof. Wood's genius was employed in the service of his country. How well he succeeded in the difficult task of devising and administering schemes for utilising to the best advantage our impoverished supplies of feeding stuffs can only be appreciated fully by his colleagues of those troublous times. His was the mind which rejoiced in propounding big ideas and schemes and, what is equally if not more important, in seeing that they were properly carried into effect. On the cessation of hostilities he returned to Cambridge, and then began the most fruitful period of his career. It was at his suggestion that the present writer began a series of investigations into the nutritive value of pasture. If, as is sometimes suggested, the results of these investigations mark an epoch in the history of grassland husbandry, let it be remembered that it was at the suggestion of Prof. Wood that the researches were begun. Also at his suggestion, his intimate friend and colleague, Dr. Capstick, devised and built the large animal calorimeter which has been such a familiar sight to visitors to the School of Agriculture during recent years. By its help, Wood and Capstick were able to carry out important and fundamental researches into the maintenance requirements of swine at all ages between weaning and slaughter. This valuable work is being continued and expanded by Dr. Deighton, who for some years past has enjoyed the privilege of close co-operation with Prof. Wood in matters relating to the practical nutritional aspects of animal calorimetry.

Ably seconded by the staff of the Animal Nutrition Institute, Prof. Wood also conducted long and laborious investigations, by the method of comparative slaughter, into the production requirements of cattle, sheep, and pigs. As a result of these researches, it is now possible to draw up tables of the precise food requirements of farm animals at all ages and live weights. Compare this happy state of affairs with the general ignorance of thirty years ago in matters of feeding and obtain in that way a measure of the debt which agriculture owes to Prof. Wood's activities. Almost his last piece of work, carried out in conjunction with Mr. Mansfield, was to measure the maintenance and production requirements of ewes and lambs, a difficult investigation which called forth a display of great experimental ingenuity.

It is not merely as an experimentalist, however, that Prof. Wood will be remembered. He has also left his mark permanently on the philosophy of the subject. At this juncture it is only possible to refer to his teachings in respect of the rationing of farm animals. He demonstrated that the method of computing rations for milk-producing animals, by summing the separate requirements for maintenance and production, could be applied with equal success to meat-producing animals. He reduced his proposals to the form of the general equation :

$$R = Am + gc,$$

where R is the net energy of the ration, A the

(*Continued on p.* 813.)

Supplement to NATURE

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Lightning.[1]

By Dr. G. C. SIMPSON, C.B., F.R.S.

WHEN we review the history of our knowledge of atmospheric electricity, we find that it can be divided into three well-marked periods.

The first of these periods opens with the suggestion made by a number of philosophers between 1730 and 1750, that the phenomenon of lightning is nothing more than an exhibition on a grand scale of the sparks which were then being drawn from the primitive electrical machines of that time. An Englishman, Stephen Gray, appears to have been the first to make this suggestion in 1735, but it was Franklin who forced the idea on the attention of men of science. Dalibard in France and Franklin in America were the first to show in 1752, by actual experiment, that electricity can be drawn from the clouds during thunderstorms.

Commencing with this startling success, the period extended for one hundred years, during which it was shown that the atmosphere is electrified not only during thunderstorms but also during fine weather, even when there is not a cloud in the sky. Numerous experiments were made, chiefly consisting of exposing insulated conductors to the atmosphere and observing their electrical state by means of crude electroscopes, generally of the pith-ball type. It was found that the electricity of the air undergoes a regular daily and yearly variation, and that the state of the weather plays a predominating part in determining the electrical state of the atmosphere. The results were, however, very vague, and as the observations were almost entirely qualitative, it was impossible to formulate any clear ideas or even to describe the results in any coherent way.

During the latter half of this first period, that is, during the first half of the nineteenth century, little progress was made and observations gave place to speculative theory. The decline of interest in atmospheric electricity coincided with the period in which the foundations of the modern theory of mathematical electricity were being laid on the classical work of Coulomb and Faraday. Amongst the pioneers of this new study of electricity was William Thomson, afterwards Lord Kelvin.

Thomson's interest in atmospheric electricity appears to have been aroused by his mathematical study of electrostatics. On May 18, 1860, he gave a Friday evening discourse at the Royal Institution on "Atmospheric Electricity", and with that lecture the second period of the history of atmospheric electricity opens. Thomson showed what the observations already made signify when expressed in terms of electrical charge on the ground and in the air. But, more important still, he introduced the idea of the electrical potential of a point in the air and showed how it could be measured and even recorded. For this purpose he invented his celebrated water-dropper, and the development of his three electroscopes—the quadrant, the absolute and the portable—was largely due to his interest in the measurement of atmospheric electricity. Electrical potential gradient in the atmosphere now became recognised as an important meteorological factor, a factor with a physical meaning and one which could be recorded continuously. In 1861 the first self-recording electrometer was installed under Thomson's direction at Kew, and this started the longest series of measurements of atmospheric electricity which exists. The series has continued to this day, although, I regret to say, not without some interruptions.

For the next forty years, work on atmospheric electricity consisted almost entirely of measurements of the potential gradient in all parts of the world, from north polar to south polar regions and from sea-level to the tops of the highest mountains. The whole of this work was dominated by Kelvin's mathematical theory and by Kelvin's methods. During this period our knowledge of the electrical field of the earth's atmosphere was greatly extended; but little advance was made in our knowledge of the causes of the electrification, and at the end of the nineteenth century the study of atmospheric electricity was again at a low ebb.

This lethargy was broken and the third period introduced by the discovery, during 1900 and 1901,

[1] The Twentieth Kelvin Lecture delivered before the Institution of Electrical Engineers on April 25, 1929; slightly abridged from the *Journal* of the Institution for November 1929 (Vol. 67, No. 395).

of radioactivity and of the existence of ions in the atmosphere. These discoveries led to renewed interest in atmospheric electricity and to the most rapid period of growth in our knowledge of the electricity of the atmosphere since the study commenced in the middle of the eighteenth century.

From this short review, it will be seen that Kelvin's work and influence played a very important part in the development of the science of atmospheric electricity. After his first epoch-making papers in and about 1860, Kelvin wrote practically nothing on atmospheric electricity ; but he was always deeply interested in the subject, especially in the problem of the thunderstorm, and those who have read his contributions to the periodic discussions on lightning at the meetings of the British Association will know of the deep interest he took in the subject of this lecture.

Conductivity of Air and Clouds.

It is scarcely too much to say that nine out of every ten physicists would be prepared to give without any hesitation an explanation of a lightning discharge. They would say something like this : " During a thunderstorm a cloud obtains a charge of electricity which goes on increasing until a spark passes to another cloud or to the ground, in the same way that an insulated brass ball discharges when connected to an electrical machine ". In other words, they consider that clouds floating in the air are conducting bodies which can be charged and discharged like any other conductors when their potential is raised sufficiently high. I hope to be able to show how completely wrong is this idea, and my best way of approach will be the historical one.

Almost from the very beginnings of electrical science, it has been known that air is not a perfect non-conductor of electricity. Charged bodies were observed to lose their charge in circumstances when there could be no leak over the insulation. At first it was considered that the loss was greatest when the air was damp, but, in 1887, Linss showed conclusively that this is not the case, for he found the loss to be greatest during fine weather when the air is dry. There was, however, considerable doubt as to the way in which the charge was lost, for it was difficult to see how a gas could be a conductor in the same way that a metal is a conductor, and it was very generally supposed that the molecules of the air striking the charged body took on a small charge which they carried away with them on their rebound. The well-known experiment in which the insulated bob of a pendulum vibrates between a charged and uncharged bell, so ringing them, was probably largely responsible for this idea. In any case it was impossible to disprove the suggestion, and it did seem to offer a reasonable solution.

The discovery of Röntgen rays and Becquerel rays led to a rapid expansion of our knowledge of the passage of electricity through gases. It was then found that the molecules of gases could be ionised ; in other words, an electron could be driven out of one molecule, leaving it positively charged, while a neutral molecule could capture a free electron and become negatively charged. A molecule of a gas charged in this way is an ion, and I shall use the word ' ion ' throughout in this sense. A positive ion, then, is a molecule of gas which has lost an electron, while a negative ion is a molecule of gas which has captured an electron.

In 1900 and 1901, Elster and Geitel in Germany and C. T. R. Wilson in England showed that clear, dust-free air always contains a number of positive and negative ions, and that it is the movement of these ions in an electrical field which makes air a conductor, the conductivity depending on the number of ions present and on their mobility. Subsequent work has shown that in the lower atmosphere there are generally about 500 ions of each sign in a cubic centimetre, and that they move with a velocity of about $1\frac{1}{2}$ cm. per sec. in a field of 1 volt per cm. A simple calculation shows that this gives to the air a small but definite conductivity, the magnitude of which is best expressed by saying that the resistivity of the lower atmosphere in clear weather is $4{\cdot}5 \times 10^{15}$ ohms. Swann has attempted to give some idea of the immense magnitude of this resistance by comparing the resistance of a column of air with a column of copper. " A column of air one inch long ", he says, " offers as much resistance to the passage of the electrical current as a copper cable 30,000 million million miles long, and of the same cross-section, *i.e.* as much resistance as that of a copper cable long enough to reach from here to Arcturus and back 20 times."

The conductivity of the atmosphere when expressed in this way may sound very small, but it is far from being insignificant. In fact, it is so large that a charged insulated conductor exposed to the atmosphere loses some 3 per cent of its charge in a minute, that is, the bulk of the charge will have leaked away through the air in half an hour.

If we turn now to the electrical conditions within a cloud, we find a great difference. Within a cloud there are practically no ïons, for even if ions are formed within the cloud as rapidly as they are formed in clear air, they cannot persist, for they are immediately absorbed by the cloud particles and lose their mobility. Thus there can be little conduction of electricity within a cloud, and a cloud is one of the best insulators we have. In fact, I myself have exposed charged bodies within clouds and been unable to observe the least loss of charge in an hour or more. We must obviously change our picture of a thunderstorm, for in place of conducting clouds floating within a non-conducting atmosphere, we have to think of non-conducting clouds floating within a conducting atmosphere—a complete reversal of the general idea. So long as we were able to think of conducting clouds, we could draw pictures like those in the text-books in which the nearest point of one cloud 'sparks' to the nearest point of another cloud, and one charged cloud induces opposite charges on the upper and lower surfaces of a lower cloud. All these pictures must be dismissed when we accept that a cloud is a perfect non-conductor, for in an insulator the charge does not collect on the surface as it does on a conductor.

Later I shall describe the process which separates large quantities of electricity into different parts of the cloud, but at present I wish to fix attention on the electricity within the cloud without considering how it gets there. Any electricity within a cloud must be carried by the water in the cloud, either on the cloud particles themselves or on the rain, hail, or snow contained within the cloud. These charges can be very great, so great, in fact, that in the strong electrical forces associated with a thunderstorm the electrical forces on the raindrops may be actually greater than the force of gravity. As the charge accumulates in a certain part of the cloud, it must ultimately discharge either to an accumulation of the opposite sign in another part of the cloud or to the induced charge on the ground below. How this discharge is initiated and then propagated is a problem which has received very little attention from physicists. A great deal is known about the discharge of electricity through air from one conducting electrode to another; but in a thunderstorm there are no electrodes, or at most one electrode when the discharge passes to or from the ground.

The Mechanism of a Lightning Discharge.

I have already said that within the cloud the charge is attached to the water particles; if, therefore, the charge is to move, it must carry the water with it. Now we know that the mobility of a water particle, no matter how highly charged, is so small that no electrical field, short of that which will break down the air, can produce an appreciable current. In other words, there can be no discharge until there is electrical breakdown of the air. I must therefore say a few words about the process of ionisation and electrical breakdown of air.

Electrical breakdown in air at normal temperature and pressure occurs when the field strength reaches 30,000 volts per cm. With this field an electron attains such a high velocity during the short time that it is free, that when it impinges on a neutral molecule at the end of its free path, it has sufficient energy to drive one or more electrons out of the neutral molecule. These released electrons are in the same intense field and they repeat the process. The effect is obviously progressive, and in a very short time there are great quantities of free electrons all moving with high velocity along the lines of force. The rapidity of motion of an electron is of an entirely different order of magnitude from that of an ion in the same field. In fact, the difference is so great that we may consider that both positive and negative ions are, when compared with electrons, quite immobile, even in the strongest fields. Now positive electricity is always carried by ions; for protons, the elementary units of positive electricity are themselves atoms of matter and therefore are ions. As soon, therefore, as air breaks down, large quantities of negative electricity can move as electrons, while the positive electricity is held immobile on the positive ions.

As electricity of one sign is accumulated during a thunderstorm in one part of the cloud, and the opposite electricity in another part of the cloud, the field between them increases in intensity. This is represented in Fig. 1 (*a*) by the + and − signs, and the lines of force are indicated. As the charge is not uniformly distributed, the lines of force are not parallel, but approach one another in the region of strongest field at the junction of the two charges.

If the field strength increases sufficiently, breakdown will first occur along the line AB. As soon as this happens, a small region becomes a good conductor and the effect is exactly the same as if a piece of wire were introduced into the electrostatic field. The lines of force assume a new distribution, shown diagrammatically in Fig. 1 (*b*), and the field becomes greatly intensified at the ends of the conducting region where the lines crowd into the conductor.

In Fig. 1 (*c*) the region of breakdown is shown on an enlarged scale. The electrons have moved rapidly towards the positive charge on the left, leaving the right-hand half of the conducting region full of positive ions which, as already stated, may be considered to be immobile. This is the condition immediately after breakdown has occurred: the subsequent changes are extremely interesting. On the diagram, arrow-heads have been added to the lines of force to indicate the direction taken by the electrons. On the left, the electrons will be dragged out of the conducting region into the surrounding un-ionised air, where they will slow up in the weaker field and be captured by the neutral molecules to form ions. These ions have little mobility and remain in a diffuse region around the end of the conducting channel.

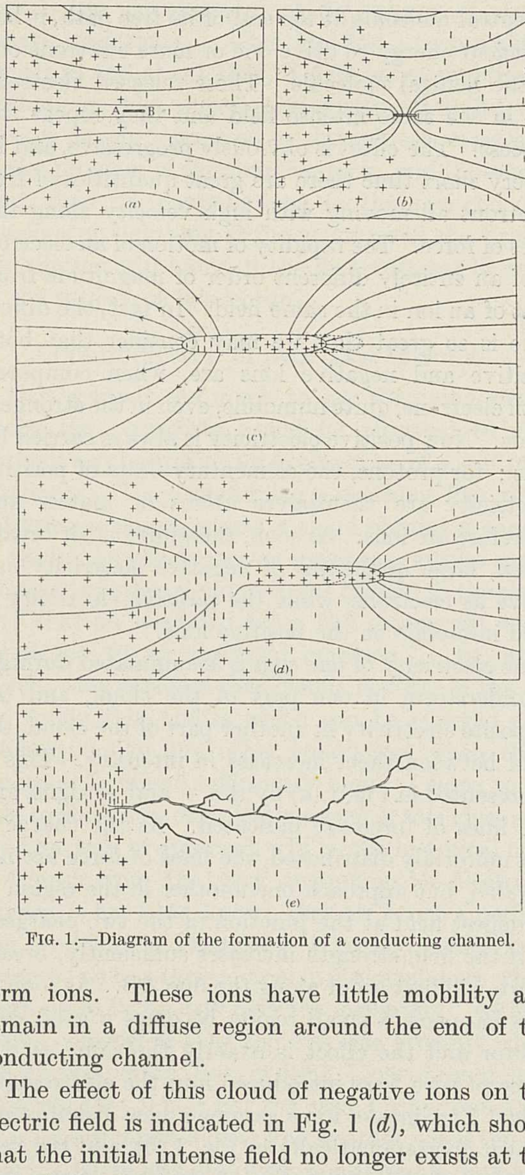

FIG. 1.—Diagram of the formation of a conducting channel.

The effect of this cloud of negative ions on the electric field is indicated in Fig. 1 (*d*), which shows that the initial intense field no longer exists at the end of the conducting region, because this region has been greatly enlarged and many of the lines of force find their ends on the negative electricity bound on the new negative ions.

If now we return to Fig. 1 (*c*) and examine the conditions at the other end of the conducting region, we find that they are entirely different. The channel is full of positive ions, but although the field tends to drag them out, they are too massive to move appreciably, and the shape of the channel remains unchanged. Owing, however, to the concentration of lines of force which took place when the air broke down, the field at the end of the conducting region is very intense, and within a space around the end of the channel, indicated by a dotted line in Fig. 1 (*c*), the air cannot withstand the stress and breaks down still further, with the liberation of further large quantities of free electrons. These electrons move at once into the conducting channel and, passing along it, keep the air within the channel highly ionised by their collisions with the air molecules. Ultimately they find their way into the cloud of negative ions at the other end of the channel. The transfer of the electrons from the newly ionised region at the end of the channel leaves that region full of positive ions; in other words, the conducting channel is simply prolonged as indicated in Fig. 1 (*d*). The process, however, cannot stop here, for the end of the growing channel remains sharp and the field at the tip is in consequence still sufficiently intense to ionise the air. Thus the channel prolongs itself rapidly in the direction opposite to the flow of the electrons, and far into regions where, before the discharge, the field was much too weak to cause the breakdown of the air.

Owing to fortuitous causes, the channel frequently branches in its growth, and we finally get a picture similar to that shown in Fig. 1 (*e*). This figure illustrates two very important properties of an electrical discharge through air at normal pressure: (1) The discharge once started makes a channel only in one direction, that direction being towards the seat of the negative electricity, while in the other direction there is no channel, only a diffuse cloud of negative ions; and (2) all the branches are in the same direction, that is, pointed away from the seat of the positive electricity. This is a most important point, for it enables us to identify the positive end of a lightning flash whenever branches can be seen.

So far, my description of a lightning discharge has been purely theoretical; but I have made a number of laboratory experiments which support the theory in all particulars. I have described these experiments in a paper "On Lightning" (*Proc. Roy. Soc.*, A, vol. 111, p. 56; 1926), and can only refer here to one experiment. Two copper discs to represent the charged region of a cloud, one positive and one negative, were placed on a photographic plate. Each disc had a small wire protuberance to concentrate the field. The discs were connected to a Wimhurst machine and a discharge was passed, with the result shown in Fig. 2. Here one sees the long, thin channels, each sharply pointed, passing out of the positively charged electrode, while from the negatively charged electrode there are no channels but only a small cloud in the immediate neighbourhood of the wire point.

Types of Lightning Discharges.

When we wish to apply these results to the lightning discharges in a thunderstorm, we have to differentiate between three possible kinds of discharges :

(*a*) Discharges between oppositely charged regions of the atmosphere ;

(*b*) Discharges between positive electricity embedded in a cloud and the ground ; and

(*c*) Discharges between negative electricity embedded in a cloud and the ground.

(*a*) *Discharges between oppositely charged Regions of the Atmosphere.*—Fig. 1 showed the form taken by the discharge between two regions having positive and negative charges respectively. As the result of the discharge we are left with a large and diffuse cloud of negative ions within the positively charged region and a channel containing positive ions probably widely branched within the negatively charged regions. The discharge has destroyed the field, but it has not distributed the transferred charge very widely : this is effected by the normal turbulence within the atmosphere, which conveys the transferred charge into the surrounding cloud, where combination with the original charge takes place and the neutralisation is completed. We see that the discharge starts where the field is most intense, and the channel grows towards and branches into the region of negative charge.

(*b*) *Discharge between Positive Electricity embedded in a Cloud and the Ground.*—In Fig. 3 the shaded area represents a cloud in which there is a concentration of positive electricity indicated by positive signs. The discharge started at the lower edge of the charged area where the field originally had its maximum value. The direction of the discharge is towards the induced negative charge on the ground, and in the course of its development the channel branched. The amount of branching will vary greatly from storm to storm, and we can have every graduation from the unbranched, meandering flash to the heavy branched discharges which appear to accompany the most violent storms.

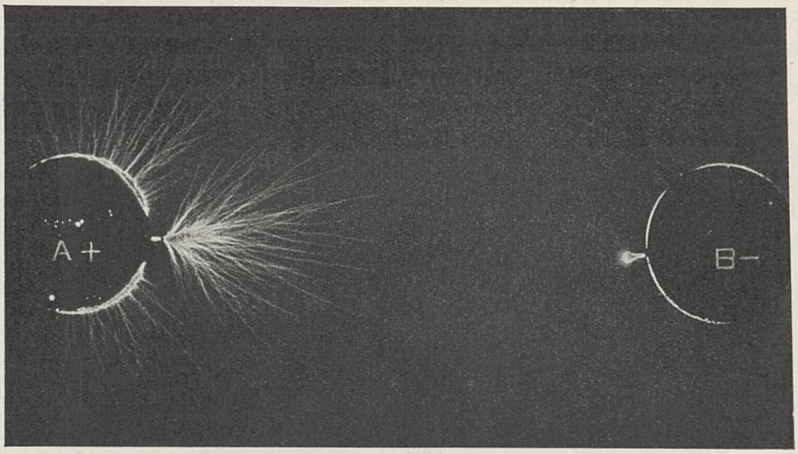

Fig. 2.—Discharges from positive and negative electrodes.

There can be little doubt that the formation of the cloud of negative ions around the end of the discharge plays an important rôle in the character of the discharge, for it reduces the field at the root of the channel and tends to prevent the flow of electricity along the channel. The channel may be actually blocked by the cloud of negative ions before sufficient negative electricity has been passed along the channel to neutralise the positive charge in the cloud. The discharge then ceases until either the block is removed or a side discharge opens a new passage between the end of the channel and another part of the cloud. In this way the discharge down the main channel may be intermittent, for the

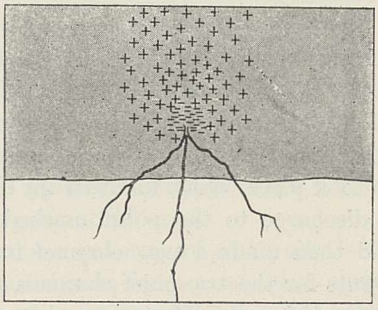

Fig. 3.—Diagram of discharge from positively charged region.

channel remains ionised for an appreciable time after each partial discharge has ceased.

The whole process as here described is well illustrated in two photographs taken by Prof. Walter of Hamburg with two cameras, one stationary and the other mounted on a revolving table. The photograph taken with the stationary camera is shown in Fig. 4. The fact that the branches converge to a point some distance within the cloud indicates clearly that the discharge did not start on the surface of the cloud, as would be the case if the cloud were a conductor. The photograph taken with the moving camera is shown in Fig. 5. The direction of motion of the camera was such that the first flash is shown on the right of the picture. It will be noticed that this was a single vertical flash. A little more than a tenth of a second later another discharge took place, which followed the channel of the first discharge to the point marked with an arrow and then made a new channel for itself—this accounts for the two chief channels shown on the stationary picture. There were then two more discharges at short intervals ; then a period when the discharge, though diminished, did not entirely cease for more than a tenth of a second ; finally, the discharge came to an end with two discharges at a short interval apart. The time interval between the first and last discharges was just over half a second.

FIG. 4.—Photograph of discharge taken with a stationary camera. (Photograph by Walter.)

In this example the branches are away from the cloud, so that there can be no doubt that the charge which gave rise to the flash was positive ; and the intermittent nature of the discharge is satisfactorily explained by the blocking of the channel by negative ions which the theory has led us to expect.

If the accumulation of positive electricity is high up within the cloud, the channels may not reach the ground but end within the cloud. Unfortunately, it is impossible to get visual evidence of such shortened flashes because they are well within the cloud. If a branch should descend so low as to reach the bottom of the cloud and become visible, it would no doubt extend right down to the ground on account of the great increase in the field at the end of the channel as the ground is approached. Although the direct evidence which would be provided by photographs of lightning flashes ending in the air cannot be obtained, there is much indirect evidence for the existence of flashes of this type in the tropics, where the whole thunderstorm phenomenon takes place much higher in the atmosphere than is the case in the latitudes of Great Britain.

(*c*) *Discharges between Negative Electricity embedded in a Cloud and the Ground.*—The field below a negatively charged cloud before a discharge passes is similar to that below a positively charged cloud, except that the direction of the field is reversed. The air again breaks down at a point near the lower edge of the charge ; but the discharge cannot this time grow towards the ground—it must develop along the lines of force into the cloud. This is shown diagrammatically in Fig. 6. Unfortunately,

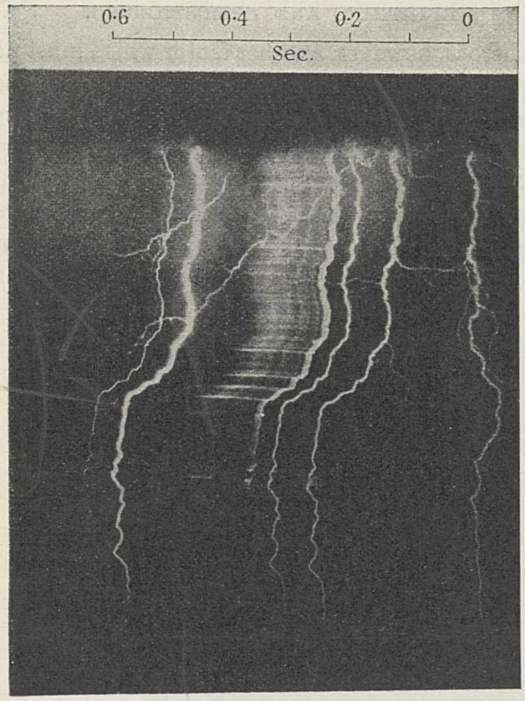

FIG. 5.—Photograph of same discharge as in Fig. 4 taken with rotating camera. (Photograph by Walter.)

it is not possible to show a photograph of a discharge of this nature, because the discharge would be entirely within the cloud and therefore hidden from the camera. There are also good reasons for believing that such discharges would be very rare, for no mechanism is known which concentrates negative electricity within a small region of the

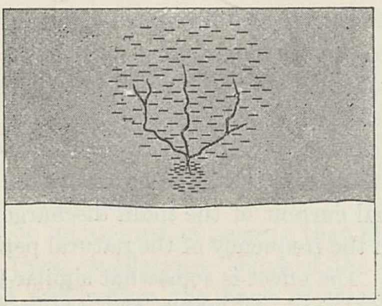

FIG. 6.—Diagram of discharge within a negatively charged region.

cloud, as is the case with positive electricity. For reasons which I shall explain later, negative electricity is generally diffused throughout a great mass of cloud. The electrical field under such an extensive cloud is relatively uniform, with vertical lines of force. The region of maximum intensity might not then be near the charged cloud but near the ground, where earth-connected irregularities such as towers, trees, hills, etc., concentrate the lines of force. If the sparking potential is then reached, it will be on one of these earth-connected projections from which a discharge will start, and the channel will develop rapidly upwards to the cloud, where it will branch as shown in Fig. 7.

It is very difficult to get photographs of flashes of this kind because the branching is nearly always well within the cloud. The finest photograph of a flash of this type which I have seen was taken by Mr. J. Craik at Herne Bay on the night of June 28, 1892 ; it is reproduced as Fig. 8.

Of the three types of discharge which we have considered—(1) the discharge within the cloud, (2) the discharge to the ground from a positive cloud, and (3) the discharge to the ground from a negative cloud—the two latter are of most importance to the electrical engineer, for it is these which strike buildings and overhead wires and do structural damage. But the characteristics of the two types of discharge to the ground are very different. The discharge from positive cloud starts high up in the atmosphere and branches out on its way to earth. An earth-connected object may therefore be struck either by the main trunk or by one of the branches. On the

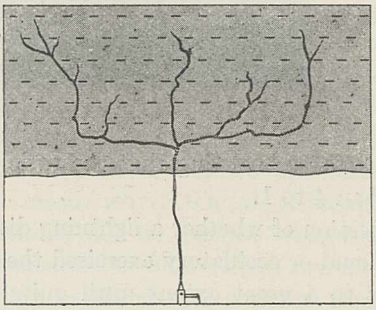

FIG. 7.—Diagram of discharge between a negatively charged region and the ground.

other hand, a discharge to a negative cloud starts on an earth-connected object, which takes the whole discharge. Thus the chances of being struck are much greater with a positive discharge than with a negative discharge.

If the same quantity of electricity is discharged from a positive as from a negative cloud, objects struck by the positive discharge will only receive a portion of the discharge, for a large part of the electricity which leaves the cloud is lost in the channel and in the branches, but an object struck by the negative discharge passes the whole electricity concerned in the discharge ; therefore negative strokes will, in general, be more intense than positive strokes. I have also shown elsewhere that positive discharges will normally be more frequent than negative discharges.

The theory which I have sketched leads to the conclusion that discharges from positively charged clouds would be frequent but weak, while discharges from negatively charged clouds would be infrequent but very strong. In order to test these conclusions, I have examined more than 400 photographs of lightning, and from the direction of branching determined the sign of the discharge. I was able to reach the conclusion that there are at least four times as many discharges between positively charged clouds and the ground as between negatively charged clouds and the ground, and there are good reasons for believing that the ratio is nearer 10 to 1 than 4 to 1.

The question of whether a lightning discharge is unidirectional or oscillatory exercised the minds of physicists to a great extent until quite recently. The question has now been finally settled by the direct observations made by Watson Watt, Norinder, and Matthias, who have shown by means of the cathode ray oscillograph that the main discharge in a lightning flash consists of a unidirectional current which starts from zero, rises to a maximum, and then decreases more or less rapidly to zero again.

In the light of the theory already given, this result is easily understandable. The essential of an oscillating discharge is a condenser which on discharging overshoots the mark, so causing a return current which recharges the condenser. So long as the cloud was considered to be a conductor which could be discharged like a Leyden jar, it was natural to conclude that lightning would be oscillatory. But we now know that a cloud is practically a perfect non-conductor and therefore has no capacity and cannot function like a Leyden jar. We should therefore expect on theoretical grounds that the main discharge would be unidirectional.

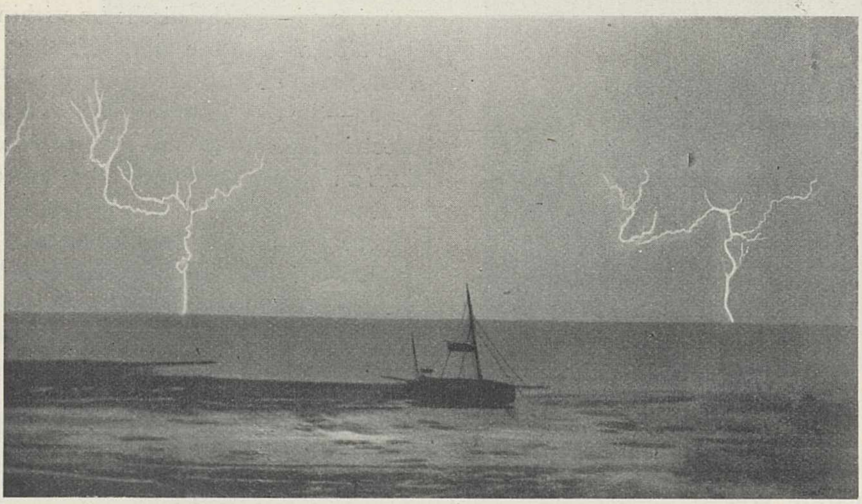

FIG. 8.—Photograph of discharge at Herne Bay. (Photograph by Craik.)

Lightning and Atmospherics.

There is, however, another factor which must not be overlooked. Although the cloud as a whole has no capacity, the conducting channel with its ramifications when once formed is a conducting system and therefore has electrical capacity and self-induction. In fact, we can picture the channel of a lightning flash to earth as a gigantic wireless aerial, and if its resistance is not too great it will oscillate like any other wireless aerial. By applying the ordinary formulæ I find that a vertical aerial earthed at its lower end, 2 km. high and 5 cm. in diameter, would oscillate if its resistance were of the order of 1 ohm per metre. There can be little doubt that the resistance of a fully developed lightning channel when most highly ionised may well be less than this and the channel therefore able to oscillate.

The oscillations will be superimposed upon the main current but will not reverse its direction of flow. In other words, the intensity of the unidirectional current of the main discharge will pulsate with the frequency of the natural period of the channel. The effect is somewhat similar to that of a 'singing arc', in which the conducting path through the air between the electrodes is maintained by a unidirectional current, while the oscillations which give rise to the musical note are superimposed upon the current according to the natural frequency of the circuit.

Now Norinder found oscillations of this nature superimposed on the lightning discharge investigated by him, and Watson Watt found them highly developed on the atmospherics which he observed in Khartoum, as will be seen from Fig. 9. If, as Appleton supposes, atmospherics owe their origin mainly to lightning discharges, these ripples find their natural explanation in the oscillations within the lightning channel, as here suggested.

The wave-length of the radiation set up by the oscillations is approximately twice the length of the channel for channels with both ends in the air, and four times the length of the channel for channels which reach the earth. If we take 2 km. or 3 km. to be the average length of a lightning channel, the order of magnitude of the wave-lengths will be 10 km., while Watson Watt found that the order of magnitude of the wave-lengths associated with the ripples he investigated was 30 km., which is a satisfactory agreement.

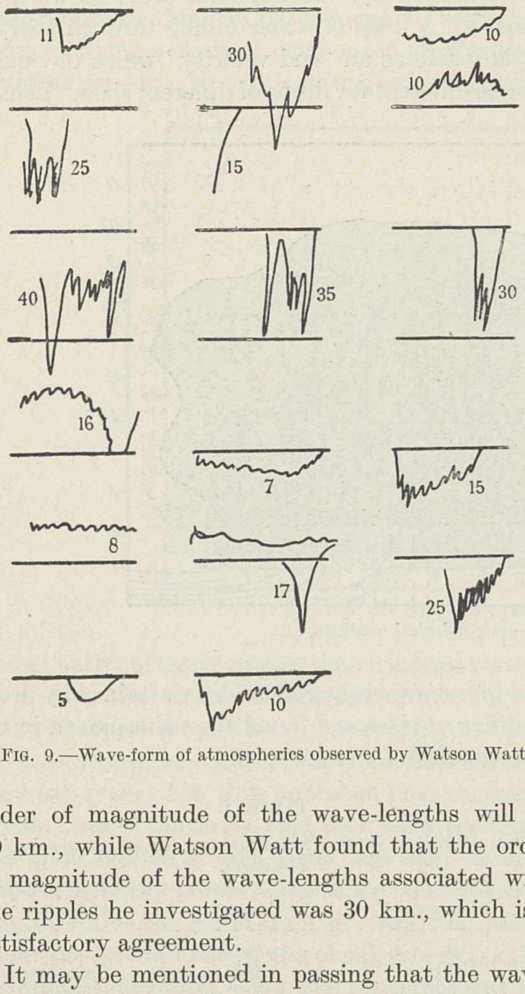

FIG. 9.—Wave-form of atmospherics observed by Watson Watt.

It may be mentioned in passing that the wave-length of these oscillations, being of the order of 10 km., is well within the band of wave-lengths used in wireless telegraphy, and therefore oscillations formed in this way are probably the chief cause of the disturbances associated with atmospherics.

Quantities and Magnitudes.

It is of importance in all practical problems connected with lightning to know the order of magnitude of the electrical factors involved. We owe to C. T. R. Wilson the best knowledge we have on these points, and I will quote here his results without any attempt to describe the beautiful methods by which he obtained the data, beyond saying that they involved measuring the change of electrical field strength produced by lightning discharges at a known distance.

Wilson finds that the quantity of electricity discharged in an average lightning flash varies between 10 and 50 coulombs, and he takes 20 coulombs as being typical. This is a surprisingly small quantity of electricity, being merely 20 ampere-seconds, a quantity which would appear to be too insignificant to call for consideration by electrical engineers. Wilson was the first to fix by direct observation the quantity of electricity involved in a lightning flash, and that so recently as 1920. Yet that great genius Faraday in his earliest experiments on electricity, when the very idea of ' quantity of electricity ' was just struggling to birth, had already obtained practically the same result. Faraday concluded that the electricity necessary to dissociate a single grain of water (700 coulombs) is " equal in quantity to that of a powerful thunderstorm ".

With regard to the potential associated with a lightning flash, Wilson estimates that the potential reached in a thunder-cloud before the passage of a discharge of 20 coulombs is of the order of magnitude of a thousand million volts. Of course potentials of this order of magnitude are never fully reached at the earth's surface when a body is struck, because of the resistance of the air channel; but there is no reason why potentials of tens of millions of volts should not be reached when conductors, such as transmission lines, which are not directly connected to earth, receive a direct stroke. The energy associated with a discharge can be calculated directly from the quantity and the voltage. It works out to be 10^{17} ergs for a flash discharging 20 coulombs. Expressed in more familiar units, the energy dissipated in an average lightning discharge is of the order of 3000 k.w.h. Again, all this energy does not appear at the earth's surface, for much of it is used in the channel, but many of the most powerful strokes must deliver a large proportion of their energy to the earth.

A very important factor in connexion with a lightning discharge is the time element. Wilson has not determined this, but we have recent measurements by Norinder and Matthias, and, if we may accept the opinion that atmospherics are due to lightning discharges, we have the large mass of data collected by Watson Watt. All these determinations agree in making the average duration of a lightning discharge greater than 0·001 sec. A discharge of 20 coulombs in 0·001 sec. gives a mean current of 20,000 amperes—a value agreeing well with the direct observations of current made by Matthias. This mean value must, however, be greatly exceeded for short periods during the course of a discharge, and we may well expect instantaneous values of the order of 100,000 amperes.

Mechanism of a Thunderstorm.

It is a great help towards understanding the varied phenomena of lightning to have some idea of the processes which build up the intense electrical fields associated with thunderstorms. Unfortunately, meteorologists are not completely agreed on this subject and no theory is universally accepted.

So long ago as 1892, Prof. Lenard showed that when pure water splashes against a solid obstacle electrification results, the water becoming charged with positive electricity while the negative electricity remains suspended in the air. In 1908 I made experiments in Simla extending Lenard's work and showed that the same separation of electricity takes place when a drop of water is broken up in the air without striking a solid obstacle.

It was natural to conclude that we have here the source of the electricity in thunderstorms. The next step was to consider the conditions under which drops are disrupted in a thunderstorm, and here again the work proceeded from previous work by Lenard. A drop of water falling through still air rapidly attains an 'end velocity' which obviously will be different for drops of different sizes. Lenard

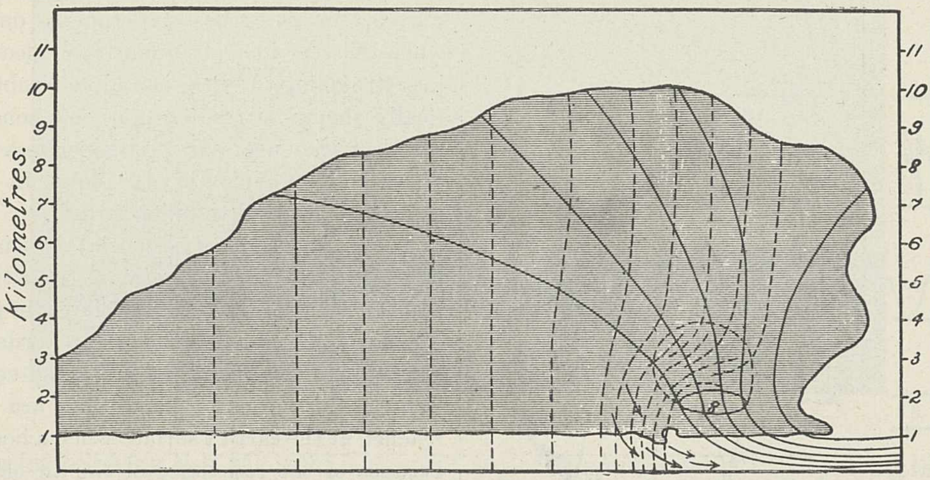

Fig. 10.—Diagram of thunderstorm—meteorological conditions.

had investigated the end velocity attained by drops of different sizes and found the values given in the lower half of Table 1.

In 1909 I suggested a theory which was amplified and worked out in detail in 1927, and as the critics of the theory have not suggested any alternative, I feel justified in giving it as at least an attempt to explain the mechanism of a thunderstorm.

Any theory of the electrical processes in a thunderstorm has to account for the initial separation of positive and negative electricity (or, shall we say, the generation of the electricity ?) and then for the transfer of the separated electricities into widely different regions of the cloud. In the theory which I am about to describe, the generation of the electricity is a consequence of the disruption of rain-drops, and is therefore called the breaking-drop theory ; while the separation of the electricity into different regions of the cloud results from the different velocities of cloud particles and rain-drops relative to the vertical air currents which are such a marked feature of all thunderstorms.

Table 1.

Rate of Fall of Water-Drops through Air at Atmospheric Pressure.

Diameter.	End Velocity.	Authority.
cm.	cm./sec.	
0·001	0·3	Calculated by Stokes's formula
0·002	1·3	
0·010	32	
0·020	126	
0·100	440	Observed by Lenard
0·200	590	
0·300	690	
0·350	737	
0·450	805	
0·546	798	
0·636	780	

It will be seen from Table 1 that the end velocity reaches a limiting value as the size of the drop increases (very nearly equal to 8 metres per sec.), above which it does not increase; it even decreases a little as the drop grows still greater. Lenard showed that this apparent anomaly is due to the drops becoming deformed, so that instead of retaining the shape of spheres they become flattened out, thus presenting an increased resistance to the air through which they fall. Owing to this deformation drops larger than about 0·5 cm. in diameter are unstable and quickly break up into a number of small drops. The practical application of this result is that water cannot fall relative to the air at a greater rate than about 8 metres per sec., and as a consequence no rain can fall through an ascending current having a vertical component greater than 8 metres per sec. Now it is a suggestive fact that violent currents much greater than 8 metres per sec. are a characteristic of all thunderstorms. Fig. 10 shows in diagrammatic form, but roughly to scale, the meteorological conditions in a thunderstorm of the heat type. The thin unbroken lines represent stream lines of the air, so that they show the direction of air motion at each point, and their distance apart is inversely proportional to the wind velocity. The air enters the storm from the right and passes under the forward end of the cloud, where it takes an upward direction. We are concerned mainly with the vertical component of the velocity, and it will be noticed that although the actual velocity decreases along the stream lines, the vertical component increases as the air passes into the storm and reaches a maximum in the lower half of the cloud. The oval marked 8 indicates where the vertical component is 8 metres per sec.; within the oval the vertical component is more than 8 metres per sec., and outside less. No water can pass downwards through this region, because the relative velocity between air and a drop having a diameter of 0·5 cm. is 8 metres per sec., and larger drops cannot exist, for they are unstable.

In the diagram (Fig. 10) the broken lines represent the paths of rain-drops. On the extreme left the drops fall practically vertically, while in the right half of the storm the falling drops are deflected to the left by the air stream. The magnitude of the deflection from the vertical will obviously depend on the size of the drops. Drops of the largest size will be little deflected, while the smallest drops—cloud particles—will travel practically along the stream lines. It is clear from the diagram without any further description that above the region of maximum vertical velocity there will be an accumulation of water. Only large drops will be able to penetrate into the lower part of this region to just above the surface where the vertical velocity is 8 metres per sec. These drops will be broken and the parts blown upwards. The small drops blown upwards will re-combine and fall back again, and so the process will be continued. The region in which this process of drop breaking and re-combining is large is indicated in the diagram by a dotted curve.

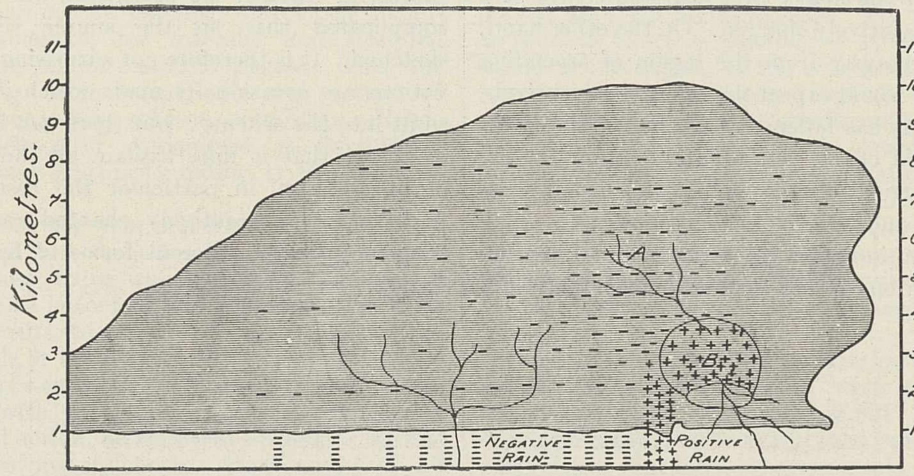

FIG. 11.—Diagram of thunderstorm—electrical conditions.

Turning now to the electrical conditions which will be associated with the meteorological conditions shown in Fig. 10, these are shown, also diagrammatically, in Fig. 11.

In the region where the vertical velocity exceeds 8 metres per sec., there can be no accumulation of electricity. Above this region is the place where the breaking and re-combining of water occurs—the region marked *B* in the figure—here, every time a drop breaks, the water of which the drop is composed receives a positive charge. The corresponding negative charge is given to the air and is immediately absorbed by the cloud particles, which are carried away with the full velocity of the air current. The positively charged water, however, does not so easily pass out of the region *B*, for the small drops rapidly re-combine and fall back again, only to be broken once more and to receive an additional positive charge. In this way the accumulated water in *B* becomes highly charged with positive electricity, and this is indicated by the + signs in the diagram. The air with its negative charge passes out of *B* into the main cloud, so that the latter receives a negative charge. The region *B* may be described as the region of separation, for here the negative electricity is separated from the positive electricity.

The rain which falls out of the region of separation will obviously be positively charged, so one would expect the heavy rain near the centre of a storm to be positively charged. On the other hand, as one moves away from the region of ascending currents, one would expect the rain to be negatively charged, for it has fallen entirely out of the negatively charged cloud. Observations made on the electricity carried by rain confirm this distribution of positively and negatively charged rain.

Fig. 11 also indicates the types of lightning discharge which one would expect to accompany the electrical distribution here described. The chief point of origin of lightning discharges will obviously be the region of separation, for here one can have unlimited concentration of positive charge carried on the accumulated water. From this positive charge, discharges may pass towards the negative electricity in the cloud, but the most frequent discharges will be downwards towards the ground, some of which will reach the ground and some will end in the air, the latter type being the more frequent in tropical storms. There will also be occasional discharges from the ground towards the main cloud, which is negatively charged. These discharges will branch upwards, while those from the region of separation will branch downwards.

This, then, is the mechanism of a thunderstorm according to the breaking-drop theory; but of course, in Nature, the conditions are much more complicated than in the simple scheme here sketched. It is therefore not surprising that observations are occasionally made which it is difficult to fit into the scheme; but there can be no doubt whatever that it does explain all the chief facts of observation, in particular the distribution of positively and negatively charged rain and the frequency of the different forms of lightning discharge.

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surface area of the animal, m its maintenance requirement per unit surface area, g its gain in live-weight, and c the energy stored in unit live-weight increase. Where A, m, and c are known, and g is given a desired value, R, the net energy of the ration to be fed for the purpose of producing the desired rate of gain of live-weight, can be calculated. He demonstrated, further, that under certain conditions of experiment, the equation can be used for computing the net energy or starch equivalent of a feeding stuff.

Space forbids more than this fragmentary sketch of Prof. Wood's scientific work. To do this justice must form the theme of some future monograph. Nor can adequate reference be made to his influence as teacher and lecturer, his gifts as author and editor, his powers as organiser and administrator. His energy was amazing. It has well been said of him that for many years there was not an agricultural project of any importance on which he was not consulted before it was finally adopted. From modest beginnings he patiently developed an imposing organisation for teaching and studying agriculture in all its manifold phases. This was his crowning achievement. He was concerned also to house his subject worthily. Hence rose the School of Agriculture at Cambridge, which fair and gracious building is his enduring monument.

So much for the man and his work. On both, posterity will pass its judgment. But to us who mourn his loss, to us who shared his labours, his aspirations, his successes, and sometimes, alas, his disappointments, to us, in these early days following his death, it is the character of the man which stands out pre-eminently. Noble and just of temperament, with an infinite capacity for kindly thought and action, he endeared himself to all who came within his influence. How many of his younger associates, amongst whom the present writer, with gratitude, numbers himself, will cherish his memory through the years to come. Truly it may be said of him: his generation was the better for his having lived.

H. E. W.

With very great regret—a regret which is shared by his hosts of friends—I have read the news of the recent death of Prof. Wood. To the value of his stimulating work in many branches of agricultural science, many competent judges will give, or have already given, their testimony with far greater knowledge than my own. I confine myself here to the personal acknowledgment of the invaluable services which he rendered during the last three years of the War to the nation and to more than one great department of State, and especially to the Board of Agriculture. I feel that I should like to add something, if I can, to the memory of a most loyal colleague.

In December 1916, when I became president of the Board of Agriculture, farming in England seemed to be almost at its last gasp. The late Lord Oxford's "Reminiscences" contain a report to the Cabinet in the preceding autumn, which presents a striking picture of the widespread sickness that had gripped the industry. If any attempt was to be made to revitalise agriculture, a definite policy must be framed and steadily pursued. The note of the German Government that, on Feb. 1, 1917, the unlimited U-boat campaign would begin, emphasised the necessity for immediate action. The problem set the Board was the production, with the greatest possible speed, of the largest possible supply of indispensable food for the needs of a beleaguered city.

In the anxieties of this gloomy period, the visits of Wood were welcome as the sun. He seemed to radiate health, energy, and cheerfulness, and his optimism, when the difficulties were so obvious and apparently so insurmountable, was invigorating. He came to me fresh from the Food Council, of which he was a prominent member, master of its latest opinions, ready, with unfailing good humour, to explain their mysteries in simple language. He proved an excellent counsellor. We had to form an idea, as exact as possible, of the food requirements of the nation, of the constituent parts of a ration which should be physiologically satisfactory, of the quantities of each constituent required, and with these facts in our minds to concert the means for their supply. On all these initial points, which included a host of subsidiary questions, Wood was most useful. But he was especially valuable in reference to the most advantageous utilisation of the live-stock of the country for our purpose. Here his practical knowledge and experience came into full play.

Nor was it only in the inauguration of the movement that Wood's services were employed to advantage. In the summer of 1917 the reserves of frozen meat for the army were running dangerously low. Until the reserves could be restored, it was decided to feed the troops at home with fresh meat. Wood served on the committee set up for the purpose, with Mr. Gavin as its secretary. The work was done so efficiently and quietly that it passed unnoticed by the country. Another work on which he was engaged at the conclusion of the War was the compilation not only of exact details of the number and age of the cattle, but also of their whereabouts, so that no district should be disproportionately depleted. He even found time to direct the work of the committee formed to disseminate among farmers information respecting the use of feeding stuffs and approved methods of alternative feeding.

I have dealt only with my personal relations with Prof. Wood, and have not referred to his work on the Inter-Allied Scientific Food Commission in Paris and afterwards in Rome. At the former conference his influence is shown in the adoption, for all allied countries except France, of the policy pursued in Great Britain on the relation of live-stock to available food supplies. His War-work is a striking record of a most unassuming and lovable man who spent his great abilities and untiring labour in the cause of his country.

Ernle.

News and Views.

THE Kelvin lecture delivered before the Institution of Electrical Engineers by Dr. G. C. Simpson, Director of the Meteorological Office, which appears in a slightly abridged form as a Supplement to this issue, will be read with interest. The valuable work Dr. Simpson has done in investigating the phenomena of lightning discharge makes everything he says worth careful consideration. In one or two places, however, he makes very definite assertions which, as our knowledge increases, will almost certainly have to be modified. For example, he says that the resistivity of the lower atmosphere in clear weather is approximately $4 \cdot 5 \times 10^{15}$ ohms. The values found for ebonite and sulphur are much greater than this, and good paraffin has a volume resistivity greater than 5×10^{18}. If air has this low resistivity, the values accepted by electricians for good insulators must be very inaccurate. We know that the resistivities of many insulators vary very rapidly with temperature, but some seem to remain constant. Dr. Simpson considers that during a thunderstorm we have non-conducting clouds floating within a conducting atmosphere, thus completely reversing our ordinary ideas. That lightning flashes could occur under such conditions will be readily admitted. We know that sparks take place readily between two pith balls. We always thought that the charge collected on the surface of an ordinary insulator. In Kelvin's theory, in which he explains the anomalous actions that occur when two pith balls of like sign are brought close together, it is assumed that the electricity is on the surface. It is difficult to believe that a cloud is a perfect non-conductor.

DR. SIMPSON'S theory of how the electrical energy is generated during a thunderstorm, the so-called 'breaking-drop' theory, can be readily accepted by the engineer. It originated in Lenard's discovery that when pure water splashes against a solid obstacle electrification ensues. Dr. Simpson then discovered that when a drop of water is broken up in the air without striking anything, the same separation of the positive and negative electricities takes place. The limiting velocity of a large raindrop falling vertically is about 8 metres per second (17 miles per hour). A drop larger than about 0·5 cm. in diameter is unstable ; it becomes flattened out and quickly breaks up into a number of small drops. When it breaks up it receives a positive charge. Now it is known that some of the air inside a thundercloud is moving with a vertical velocity greater than eight metres per second. The resulting negative charge is given to the air and is absorbed by the cloud particles which are being carried upwards. We would expect, therefore, that the rain which falls where the air currents are vertical would be positively charged and that at a distance from this region it would be negatively charged. This is in accordance with observation. There will be occasional discharges from the earth to the negatively charged cloud, but the most frequent discharges will be downwards towards the ground, some of them apparently ending in the air. We hope that this lecture will give an impulse to the study of the phenomena of lightning, as, notwithstanding recent advances, there are still many difficulties to be explained. The phenomena of chain lightning and globular lightning have not been considered. An explanation of these curious occurrences would probably reflect light on the mechanism of an ordinary thunderstorm.

THE Nobel prize for physics for 1928 has been awarded to Prof. O. W. Richardson, for his researches upon the emission of electricity from incandescent materials, and in particular for his investigations of the laws governing the rate of emission of electrons. Prof. Richardson is a Yarrow research professor of the Royal Society, but continues to direct the research work of a large number of students at King's College in the University of London, where he held the Wheatstone chair of physics from 1914 until 1924. Richardson virtually created the subject of thermionics, and so long ago as 1901 " showed that the negative ionisation from hot metals could be satisfactorily explained by supposing that it was caused by the freely moving corpuscles inside the metal escaping from the surface when their kinetic energy exceeded a certain value ", to quote from a paper by him in the *Proceedings of the Royal Society* for 1906. His monograph on " The Emission of Electricity from Hot Bodies ", which first appeared in 1916, goes almost so far as is possible without the aid of the new mechanics and the refined vacuum methods developed afterwards in connexion with technical applications of thermionics. Richardson's " Electron Theory of Matter " is also well known to students of electricity and atomic physics, and although published between the advent of the Bohr and the Wilson-Sommerfeld theories of the atom and with a strong classical bias, is still much used. Richardson has made numerous important contributions to other branches of atomic physics, the most important of which are perhaps his extensive investigations of soft X-rays by electrical methods, and his unravelling of bands from the complicated molecular spectrum of hydrogen.

THE work for which the Duc de Broglie has been awarded the Nobel prize for physics for 1929 is of more recent date, and will be familiar to most readers of NATURE. Looking back now at his earlier work on the undulatory theory of matter, it would appear that the path of approach to the idea of the material wave was primarily from the realm of optics. de Broglie's important paper in the *Philosophical Magazine* for 1924 (vol. 47, p. 446) is entitled " A Tentative Theory of Light Quanta ", and it is in this that he develops the analogy between the principles of Fermat and of Maupertuis, and shows how " the Lorentz-Einstein transformation joined with the quantum relation leads us necessarily to associate motion of body and propagation of wave, and that this idea gives a physical interpretation of Bohr's analytical stability conditions ". The criticism which de Broglie anticipated would be accorded to these then novel views has been constructive rather than otherwise, and it is by now an old story how his predictions have been verified by the experiments of G. P. Thomson, Rupp, Kikuchi, and others, and how his ideas have been elaborated by Schrödinger and incorporated in the present fabric of the quantum theory.

The Nobel prize for chemistry for 1929 has been divided between Prof. Arthur Harden, head of the Biochemical Department at the Lister Institute and professor of biochemistry in the University of London, and Prof. Hans von Euler-Chelpin of Stockholm. Prof. Harden, who is also one of the editors of the *Biochemical Journal* and an original member of the Biochemical Society, is perhaps best known for his work on the alcoholic fermentation of yeast: nearly twenty years ago he published a monograph on this subject, as one of the series of Monographs on Biochemistry, which has recently reached its third edition. He is the author (with W. J. Young) of papers on the co-ferment of yeast juice and the function of phosphates in the fermentation of glucose by yeast juice: from the latter observations has developed our knowledge of the place of hexose phosphates in carbohydrate metabolism, and it is now known that these substances play an important part not only in the yeast plant but also in higher animals as well, especially in the process of glycogen synthesis and breakdown, and hence in muscular contraction. Prof. Hans von Euler-Chelpin, who is professor of chemistry in the Technical High School, Stockholm, has also made noteworthy contributions to our knowledge of the chemistry of enzymes.

One hundred years ago—in 1829—the Royal Society made no conferment of its Copley medal, and doubtless at the time there was adequate reason. Originally, the small sum attaching to Sir Godfrey Copley's legacy was devoted to experiments for the Society's own advantage, but on Nov. 10, 1736, "Mr. Folkes proposed a Thought to render Sir Godfrey Copley's Donation for an Annual Experiment more beneficial than it is at present, which was to convert the value of it into a Medal, or other honorary prize, to be bestowed on the person whose experiment should be best approved: by which means he apprehended a laudable emulation might be excited among men of genius". The idea met with approval, and on Dec. 7 following, the president and council resolved "that instead of Sir Godfrey Copley's Annual Donation of Five Pounds, a Gold Medal should be struck of the same value, with the Arms of the Society impressed on it, and that the same should be given as a voluntary reward, or honorary favour, for the best Experiment produced within the year, and bestowed in such a manner as to avoid envy or disgust in rivalship". In 1756 the experiment provision was repealed, and there are now no time limitations, nor is the nationality of the recipient incidental to award. In 1766 triple awards of the medal were made, these respectively to William Brownrigg, Edward Delaval, and the Hon. Henry Cavendish. In 1840, Liebig and Sturm each received a medal, but since that date a single yearly allotment has been the rule.

As regards the two Royal medals, no intermittance occurred in 1829; the recipients were Charles Bell, and Eilhard Mitscherlich, of Berlin. The grounds of award for the former were "his Discoveries relating to the Nervous System"; for the latter, "his Discoveries relating to the Laws of Crystallization and the Properties of Crystals". Sir Charles Bell (he was knighted by William IV.) was born at Edinburgh in 1774. In early manhood he was already an anatomist of repute, and a convincing lecturer. His essay, "A New Idea of the Anatomy of the Brain" (1811), contained the discovery of the distinction between sensory and motor nerves. Bell died in 1842. Mitscherlich was born at Neuende (Oldenburg) in 1794, and died in 1863. Orientalist as well as chemist, he worked for some time with Berzelius at Stockholm, becoming afterwards professor of chemistry at the University of Berlin. His observation that corresponding phosphates and arsenates crystallise in the same form was the germ of the theory of isomorphism, communicated to the Berlin Academy, of which he was a member, in 1819.

The recent statement on the radium problem issued by the Radium Commission contains a much-needed warning against the exaggerated views on the possibilities of the therapeutic action of radium which have recently found expression in the daily Press. The problem presented by the treatment of cancer can only be properly understood by reference to the pathology of the disease. Cancer arises locally as a primary tumour. The primary tumour continues to grow locally and at the same time spreads, mainly through the lymphatic channels, to the neighbouring lymph glands. From there it spreads eventually to the more distant glands and to the internal organs, where the malignant cells grow as secondary deposits or metastases. Cancer can be cured with certainty in its earliest stage so long as it has remained a localised growth. It can then either be removed surgically or it can be destroyed by treatment with radium. Even when the malignant cells have begun to spread to the neighbouring glands, the cure is still possible if all the affected glands can be removed surgically or be subjected to treatment with radium. The recent advances in radiotherapy consist essentially in the fact that it has been possible to introduce radium, in the form of radium needles or of seeds containing radium emanation, into the growth and the surrounding tissues, so that a uniform irradiation of the growth and surrounding tissues can be ensured, and the malignant cells can be destroyed with certainty in the irradiated area.

The difference between surgery and radiotherapy consists therefore in principle in the manner in which the attempt is made to free the cancer patient from malignant cells. Surgery does so by removing the tissues containing the malignant cells; radium destroys them *in situ*. Both methods suffer from the difficulty that their application is limited by the accessibility of the organs which are likely to be affected. There is no evidence that the destruction by radium of the accessible malignant cells confers upon the body the ability to rid itself of the malignant cells in the non-accessible site. In a word, radium is not a ' cure ' for cancer, but, like surgery, a treatment for cancer. As with all other treatments, its success depends upon the skill and knowledge of the operator and, what is most important, on the stage of the disease at which it is applied. Early diagnosis is as important for the successful treatment by radium as for the successful treatment by surgery. One great point in favour of radium is that its use does not involve the risks and suffering associated with extensive and mutilating operations. There is therefore a reasonable hope that, with prospects of a cure without mutilation, patients should be far more ready to consult their doctors at an early stage so as to ensure early diagnosis.

On Friday, Nov. 15, Sir William Bragg opened an exhibition of historical scientific apparatus belonging to the Royal Institution, which for the time has been removed to the Science Museum, South Kensington, while the alterations in Albemarle Street are being carried out. The exhibition has been arranged by permission of the Board of Education and with the aid of the staff of the Museum, and it will remain open to the public during the winter months. Founded by Rumford in 1799, the Royal Institution has been the home, study, or laboratory of Rumford himself, Davy, Young, Brande, Faraday, Tyndall, De la Rue, Rayleigh, Dewar, and other eminent men of science, and much of the apparatus used in their experiments has been preserved. We understand that altogether there are some 1200 pieces of apparatus, and that about 250 of these have been placed on view in the gallery near the Exhibition Road entrance of the Museum. Much care has been taken with the labelling, and it may perhaps be suggested that many visitors would like to be able to procure a brief catalogue for future reference. In opening the collection, Sir William Bragg referred to some of the more important exhibits and paid an eloquent tribute to the work of Faraday and others.

The exhibits are arranged chronologically, beginning with those of Rumford, who experimented on heat, and ending with some X-ray apparatus illustrating the work being done at the Royal Institution at the present time. Of the exhibits we may mention the electric batteries provided by the Royal Society for Davy, and Davy's and George Stephenson's miners' safety lamps. Of Faraday's apparatus there is the original sample of benzene which he separated for the first time in 1825, the world-famous iron ring with which in 1831 he discovered electromagnetic induction, objects illustrating his work on magnetism, compression tubes used for his experiments on the liquefaction of gases, and specimens of his own making showing the very beautiful sand figures formed under rippling water. Tyndall's work is recalled by the apparatus he used for the study of heat absorption by gases and vapours, his fifty-year old broths used for disproving the spontaneous generation of life, while Dewar's work is illustrated by a series of vacuum vessels, a liquid hydrogen calorimeter, a little gas thermometer, and his beautiful soap bubble apparatus. While referring to this exhibition, we think the attention of the Office of Works should be directed to the inadequate artificial lighting of some of the galleries of the Museum, rendering the close examination of the objects and the reading of the labels unnecessarily trying.

A novel suggestion in connexion with the shearing of South African sheep has been made by Prof. A. F. Barker, professor of textile industries in the University of Leeds, as a result of his observations in South Africa during the recent meeting of the British Association. Prof. Barker suggests that, instead of letting the sheep grow a twelve months' (or even eight or ten months') fleece, thereby creating difficulties which the manufacturer may only be able partially to overcome, the wool should be sheared to manufacturing requirements, say from 1 in. to the maximum length of staple, just as required. The desirability of this procedure, he alleges, is confirmed by experimental work carried out at the University of Leeds, which indicates, *inter alia*, the value of equality of length of fibre and maximum length beyond which there is disadvantage rather than advantage. So far a summary only of Prof. Barker's report has been published, and his suggestion appears to be of limited academic interest. The British Wool Federation, the principal trade organisation of the raw wool industry, is inclined to view the suggestion with scepticism, for it writes that " the suggestion that a fleece which might grow to 8 in. long might be sheared in so many separate inches at various times of the year to the advantage of the farmer is beyond the comprehension of those who have been engaged in the Cape wool trade for many years past ".

On Nov. 16 General Smuts delivered the third and last of his Rhodes Memorial Lectures at Oxford after receiving the honorary degree of D.C.L. in a special meeting of Convocation. The subject of the lecture was " Native Policy in Africa ", a subject which he described as part of the great question of colour and civilisation destined to become the dominant issue of the twentieth century. The lecture was an eloquent, yet at the same time closely reasoned, exposition of the policy of ' segregation ' in South Africa, which neither sought to minimise the mistakes of the past nor to pass over the difficulties which have to be faced in the near future. In both General Smuts finds lessons which may be a warning to the newer communities of other parts of Africa in finding a solution of their own native problems. The policy of segregation, which General Smuts traced back to the innovations of Cecil Rhodes in dealing with native affairs, contemplates, as is well known, the absolute separation of the white and native communities, the latter administering their own local affairs on their reservations.

As General Smuts pointed out, owing to the failure of both administrators and missionaries to appreciate the bearing of the results of the study of anthropology, instead of advancing the native they have helped to disintegrate native institutions and many steps had had to be retraced. Hence there are serious problems to be faced in South Africa to-day which other African communities with this example in view may succeed in avoiding. Of these, one is the detribalised as well as the educated native to whom the policy of segregation cannot be made to apply—a source of both economic and political difficulty; and secondly, the question of representation of the native in the supreme legislature. An intense sympathy for native institutions and a desire to secure the advancement of the native along lines in harmony with his culture informed the whole of General Smuts' lecture. In years to come it will rank as one of the most important statements on native policy ever made by an Imperial statesman.

Lord Bledisloe's offer to the nation in perpetuity of the Roman camp in his deer park at Lydney, Gloucestershire, is a public-spirited action which we hope will be appreciated at its full value, having in view the nature of the site. It will be remembered that the exploration of this camp was undertaken by the Society of Antiquaries and has been completed only recently. In certain respects, the site as a monument of antiquity is unique. It is a small hut-town standing on a commanding promontory jutting out from the Forest of Dean. Within its limits, it would appear to have been of some importance as a centre of iron-working and it includes within its boundaries the only iron mine yet found which can definitely be ascribed to the Roman period. According to an account in the *Times* of Nov. 15, the shaft of the mine is 1 ft. 6 in. to 2 feet wide and dips at an angle of 20°. It has been partly explored. On examination it was found that the surface of the rock still showed the marks made by the Roman miners.

The main interest of the site, however, and the feature which makes its offer to the nation peculiarly welcome and appropriate, is the fact that we have here in this one area the evidence of a completed phase of British culture. The settlement begins with a civilisation still making use of bronze and showing affinities with Glastonbury and Meare, passes through a stage in which the native crafts give way to those of a Romano-British culture; and this in turn passes into a post-Roman phase in which the inhabitants sink back into a state of barbarism. One of the most interesting features of the site is the temple of Nodens, erected about 365 A.D., which, the evidence would suggest, was a great centre of healing. It may not be out of place to recall that Gloucestershire is one of the English counties rich in Holy Wells, which were at one time centres of healing, so that the cult of Nodens may perpetuate a still earlier cult. A debt of gratitude is due to Lord Bledisloe for an offer which will ensure the preservation of so interesting and important a site.

At last a Committee has been appointed by the Government of Great Britain to consider whether it is desirable and feasible to create a national park. The attention of all concerned might profitably be directed to a 9-page pamphlet, issued as *Miscellaneous Publication*, No. 51, by the United States Department of Agriculture (September 1929). It gives a list of the national wild life reserves in the United States and indicates that the very argument which has been used against the creation of such areas in Great Britain, namely, the increase in population and the more intensive use of land, is just the argument which has led in America to the special protection of beasts and birds in reserves. Eighty-two areas, ranging in extent from rocky islets of 5 acres to the 2,000,000 acres of the Yellowstone Park, are administered by the Bureau of Biological Survey. They have been chosen primarily for their suitability for forms of wild life that have become greatly reduced in numbers or threatened with extinction. Some, even of great extent, are fenced for such large game animals as buffalo, antelope, mountain sheep, and wapiti. In addition to these areas, deliberately set apart as wild-life reservations, there are areas within national forests set aside for the protection especially of big-game animals; and wild life is given further protection in such places as national parks, national monuments, and lighthouse reservations, administered by other branches of the government for scenic, historical, or other special purposes. Surely here are hints in abundance for the creation of simple reserves in Great Britain.

We have received from several correspondents comments on Mr. C. W. Marshall's letter on the magnetic reaction of the glowing filaments of carbon incandescent lamps which appeared in our issue of Nov. 9, p. 727, with a photograph giving an excellent impression of the visual appearance of the filament when vibrating. The phenomenon has been well known for at least forty years to electricians who are familiar with alternating currents. We agree with our correspondents in thinking that it can be satisfactorily explained by ordinary dynamical and electromagnetic principles. Forty years ago, Prof. Ayrton showed that if the wire of a monochord were of steel and carried an alternating current, and a magnet was brought close to the wire, small vibrations usually ensue. If, however, the weight be adjusted, we get a large vibration when resonance ensues. About a year afterwards, Dr. A. Russell varied this experiment by using an alternating current electromagnet, no current passing through the monochord wire. In this case, very large oscillations were obtained when resonance ensued. If l be the length of the wire in centimetres, m the mass of unit length of it in grams, and T be its tension in dynes, we have $f = \sqrt{T/m}/(4l)$, where f is the frequency, that is, the number of complete cycles of the alternating current.

This method of measuring frequency is well known in many electrical laboratories and is a very satisfactory one. The formula is deduced from ordinary dynamical and electrical principles. In the case of a glowing filament, whether of carbon or metal, having a few turns and carrying an alternating current, the helical part of the filament acts simply as an A.C. magnet, the polarity of the ends continually changing. Bringing up a permanent magnet produces repulsive and attractive forces on the filament and so it vibrates. We have often seen in an electrical laboratory a magnet brought near a coiled filament lamp, causing the filament to vibrate. Sometimes the vibrations are so large that the incandescent filament hits the glass bulb, causing the glass in contact with it to melt and so letting in the air and burning out the lamp.

The *Realist* generally contains good articles, but there is unusual suggestiveness for the biologist in Prof. Julian Huxley's analysis of the size of living things, which appeared in the September and October issues. In the earlier number are given some striking size contrasts, and a skeleton classification of organisms grouped according to size emphasises some curious relations. The largest of living organisms are the big trees of California; the largest animals that have ever lived are whales. The smallest vertebrate is a frog—less than a queen bee, less than some of the Foraminifera. There are molluscs which belong to the same order of size as elephants, jelly-fish which rank with cattle and red deer. A diagram illustrating twenty-seven different organisms according to scale makes a series of vivid comparisons. The second article discusses the biological implications of size, and while it does not help to solve how animals attained their adjustments, it shows how the privileges and penalties of size have limited the course of evolution. Here also curious relations are brought out: the individual man is all but half-way between atom and star; humanity entire stands in the same position between electron and universe.

William Froude's original experimental tank for model trials of ship's hulls, which he built at Chelston, near Torquay, has been followed by many larger and better equipped tanks, of which the latest is the Italian National Experimental Tank in Rome, the opening of which took place on Nov. 3. An illustrated article on this new tank appears in the *Engineer* for Nov. 15, where it is described as "noteworthy as being the best equipped and, from the point of view of its harmonious dimensions, probably the finest tank of its type in the world ". Constructed of reinforced concrete, the tank has a length of 275 m. (902 ft. 3 in.), a breadth of 12·5 m. (41 ft.), and a depth of 6·3 m. (20 ft. 7½ in.). The main carriage is designed for a maximum speed of 12 m. per second, and is adapted for testing hydroplane models as well as ship models and propellers. The model-shaping machine is designed to take a model 8 m. (26 ft. 3 in.) in length, and an interesting piece of apparatus designed by Dr. Gebers, the superintendent of the Vienna tank, is a measuring table furnished with micrometers in three directions, enabling the hull appendages, bilge keels, hull axis, and the propellers to be set in position on the hull with absolute accuracy.

The provision of sufficient illumination is only a part of the problem of providing adequate lighting. Of equal importance is the avoidance of glare, a phenomenon which is familiar but not very easy to define. At a meeting of the Illuminating Engineering Society on Nov. 8, Mr. W. S. Stiles drew a distinction between ' disability glare ', which is manifested when a bright source in the field of vision impairs the ability of the eye to distinguish small contrasts, and ' discomfort ' glare, of which it is difficult to devise any ready test. Instructive experiments showing how the power of the eye to detect discs stencilled on a slightly darker background is affected by the presence of an unshielded electric lamp were performed. A demonstration of a method of evaluating glare based on the comparison of a lighting unit with a series of globes containing lamps of different candlepower was given. The intensity of glare is determined by a number of factors, such as the brightness (c.p. per sq. in.) of the source, its position in the field of view, its distance, and the nature of the background. Attempts have been made to express the influence of these factors by equations. Possibly, as was suggested in the discussion, glare is best regarded as due to excessive contrast in brightness. Early investigators considered that glare would be absent if the contrast in brightness of objects visible to the eye did not exceed 100:1, a condition that can be approached without undue difficulty in interiors, but seems almost impossible to realise in lighting streets and open spaces. What has long been needed is a simple test for determining quickly the degree of glare in an installation. Until this is available one is obliged to rely upon more or less empirical rules.

Applications are invited for the following appointments, on or before the dates mentioned :—A visiting instructor of stained glass at the Central School of Arts and Crafts, Southampton Row, W.C.—The Education Officer (T.1), County Hall, Westminster Bridge, S.E.1 (Nov. 25). A lecturer in applied and pure mathematics in the University of St. Andrews—The Secretary and Registrar, The University, St. Andrews (Nov. 29). An assistant lecturer in the Department of Education of King's College, London—The Secretary, King's College, Strand, W.C.2 (Nov. 30). A lecturer in physiology in the University of Birmingham—The Secretary, The University, Birmingham (Dec. 3). A junior inspector under the Ministry of Agriculture for Northern Ireland—The Secretary, Civil Service Commission, 15 Donegall Square West, Belfast (Dec. 3). A lecture assistant in the Department of Physics of the University of the Witwatersrand, Johannesburg—The Secretary, Office of the High Commissioner for South Africa, Trafalgar Square, W.C.2 (Dec. 6). An assistant lecturer in chemistry at University College, Southampton—The Registrar, University College, Southampton (Dec. 16). A resident tutor for chemistry and rural science (plant biology and gardening) at the Winchester Diocesan Training College—Rev. the Principal, Diocesan Training College, Winchester. A part-time teacher for evening classes in brickwork in the School of Architecture, Building, and Surveying, of the Polytechnic, Regent Street—The Director of Education, The Polytechnic, Regent Street, W.1. A half-time assistant in the Department of Mathematics of the University College of Swansea —The Registrar, University College, Singleton Park, Swansea. Two junior researchers under the National Research Council of Canada for research work on, respectively, heat and aeronautics—The Secretary, National Research Council of Canada, Ottawa, Canada. An assistant chemist under the Research Association of British Paint, Colour, and Varnish Manufacturers —The Director, Paint Research Station, Waldegrave Road, Teddington.

Research Items.

Purification of Swimming Bath Water.—Reports appear from time to time suggesting that disease may be spread by swimming baths, and as the provision and use of swimming baths has increased greatly in recent years, the Ministry of Health has been well advised to institute an inquiry into the subject, the report of which has recently been issued ("The Purification of the Water of Swimming Baths." London: H.M. Stationery Office. Price 1*s.* net). When the water is infrequently changed, or is not subjected to purification, pollution must occur, chiefly from the persons of the bathers and from their costumes, and diseases may occasionally be transmitted, but there is no evidence to support the alarmist rumours that appear. Natural purification can be relied upon only when the pool is of considerable size, and the inflow of fresh water is sufficient. In smaller baths and pools, frequent change of water ('fill-and-empty system') is usually too costly, and some system of purification becomes necessary. For this purpose, filtration and aeration are useful, but some form of chlorination is to be preferred. Filtration with continuous chlorination is the method advocated, the chlorine being derived from bleaching powder, electrolytic fluids, chlorine gas, or chloramine. All these methods are described and discussed.

Human Chromosomes.—The number of chromosomes and the character of the sex chromosomes in man appear to be settled by a memoir of Prof. H. M. Evans and Dr. Olive Swezy (*Memoirs Univ. of California*, vol. 9, No. 1). The male germ cells from six individuals were studied, one of whom was a negro and one a Mexican. The number of 48 chromosomes was confirmed, and, in addition, the occurrence of an XY pair of sex chromosomes appears to be proved. Immediate fixation is a first essential in obtaining good material for study. The thread stages of the heterotypic mitosis were traced. The XY pair of chromosomes forms a pear-shaped chromatin nucleolus, and the chromatin threads pair laterally in the bouquet stage. Half the primary spermatocytes receive the Y-chromosome, which is the smallest of the chromosomes, and half receive the medium-sized X-chromosome. In the second meiotic division the Y-chromosome is shown to divide, the haploid number of chromosomes being 24. The chromosomes of young human embryos were also studied, a white embryo of 23 mm. length being male, since its 48 chromosomes included a Y, and a Japanese female embryo having no Y but presumably XX, since the X pair are not clearly distinguishable in size from certain other pairs. Sections from the uterus of a negress again showed the female complement of chromosomes, and sections of a carcinoma from the lip of a man showed the Y-chromosome in each cell. There was no indication of a range of chromosome numbers in cancer tissue when fixed immediately after removal. The majority of the cells had 48 chromosomes of the ordinary somatic type, but some enlarged cells were found with what appeared to be 48 tetrads. This finding should lead to a reinvestigation of the cytology of cancerous tissue. Another conclusion which the authors emphasise is that if chromosome-lengths from male and female cells are compared, the largest pair in the male is slightly longer than the largest in the female, both in embryonic and adult tissue. This is regarded as a secondary sexual difference resulting from the presence of the Y- instead of an X-chromosome.

'Mountain Beavers' of America.—Popular names could scarcely be more misleading than in the case of these tailless rodents belonging to the genus *Aplodontia*. They are not beavers, and they are scarcer in the mountains than in the lowlands; in Oregon they are known as 'boomers', but they do not boom; in other districts as 'whistlers', but they cannot whistle. They are herbivorous burrowers which frequent the Pacific coast region of southern British Columbia, Washington, Oregon, and northern California. In their natural haunts, in the seclusion of the forest, they do not interfere with human interests, but the clearing of lands and extension of farming have offered new food supplies, and the mountain beavers have increased in numbers to such an extent that in many localities they have become serious crop pests. Their fur is of no commercial value, and the control of their numbers in areas where they cause serious damage resolves itself into the most efficient methods of trapping and poisoning. These are discussed by Theo. H. Scheffer in *Farmers' Bulletin*, No. 1598, of U.S. Dept. of Agriculture (August 1929). Fortunately, there need be no campaign of extermination against these rodents, since they are harmless throughout a thousand miles of their coast range.

Zoogeography of Java.—There are many significant facts in Dr. K. W. Dammerman's account of the zoogeography of Java (*Treubia*, vol. 11, p. 1; 1929), which contains full lists of the species of mammals, birds, reptiles, amphibians, fresh-water fishes, and land and fresh-water mollusca, but we can refer here to only one general result. It is well known that there occur in Java a number of animals which are absent from Sumatra or Borneo, or even from the Malay Peninsula, but reappear in some remote part of the Asiatic continent. The ingenuity of zoologists has been taxed to explain this anomalous distribution. Wallace first invoked a Java-Siam land-bridge, and later the influence of the glacial period; others have raised an imaginary land-bridge by way of the lesser islands west of Sumatra. But a closer analysis of the facts shows that the remarkable resemblance to the fauna of distant regions is mainly exhibited amongst bats and birds, in a far less degree amongst reptiles, almost negligibly amongst amphibia, fresh-water fishes, and mollusca (in the last case in 8 out of 370 species). It is clear that the bats and birds may have moved unhindered by short stretches of sea, and of the other creatures, it is remarkable that the remote resemblance does not hold good for the animals most in need of land-bridges. The question is not one of land-bridges, but a biological problem concerned with the disappearance of certain creatures from the intermediate areas.

Aquarium Keeping.—Lieferung 271 of Prof. Emil Abderhalden's "Handbuch der biologischen Arbeitsmethoden", Abt. 9. Methoden der Erforschung der Leistungen des tierischen Organismus, Teil I. 2 Hälfte, Heft 6, consists of an elaborate treatise by Dr. Wilhelm Klingelhöffer describing in detail the technique of aquarium keeping: "Einrichtung von Zimmer- und Freiland Aquarium und Terrarien einschliesslich der Technik der Haltung und Zucht von Fischen, Reptilien und Amphibien, 1928". The making of an aquarium is first discussed, with details of all materials for construction; then the heating and aeration. Small jars and tanks for the room and large fresh- and salt-water aquaria are described, the Frankfurt aquarium being taken as a model. A large portion of the work is given up to the fresh-water aquarium—its management, chemical constituents of the water, and the interaction of its plants and animals, with a discussion on hydrogen ion concentration—the best weeds and the best animals to place in it. Diseases of the fishes are described, protozoan or bacterial, or those due to worms and crustacea, food and instructions for collecting it, snails and crustacea and their needs, and the breeding of fishes, both British and foreign. Much less space is devoted to sea-water aquaria, and this is almost entirely confined to the small kinds which can be placed practically anywhere. The advice given, however, is excellent and should be very helpful considering the many creatures which can now be successfully kept in sea-water aquaria far from the sea. The final part deals with amphibia and reptiles, and the rearing of these animals in captivity. Here the value of 'vita' glass and its varieties is shown, and there is an interesting chapter on those garden-like enclosures which may consist of aquaria, aviary, and vivaria, described as *Freilandanlagen*.

Copepods of the *Terra Nova* Expedition. — Mr. Farran's account of the *Terra Nova* copepods includes much that is of interest (British Antarctic (*Terra Nova*) Expedition, 1910. Natural History Report. Zoology. Vol. 8, No. 3. Crustacea. Part X. Copepoda. By G. P. Farran, British Museum (Natural History), 1929). Apart from the fact that he records 231 species, 18 of which are new, his notes on many well-known and widely distributed forms are of great value and help us much towards a knowledge of this important group of planktonic crustaceans. *Calanus finmarchicus* from the southern hemisphere differs from the normal north temperate form in its smaller size and reduced number of teeth on the first basals of the fifth leg. The author suggests that it may be a different race. *Metridia lucens* reaches to within the Antarctic Circle, *Oithona similis* is common in hauls made under the ice, occurring over the whole area traversed from New Zealand to the Ice Barrier, *O. plumifera* occurs almost everywhere, excluding the Antarctic Circle. *Acartia clausi*, here regarded as indistinguishable from the *A. aurifera* of Brady, is common off New Zealand, and one specimen was found close to the equator. *Paracalanus parvus* occurs all over the area traversed as far south as 43° 52′ S. All these are common forms in the northern seas. The large *Rhinocalanus gigas* Brady, which may measure as much as 8·7 mm., is separated by the author from the more widely distributed *R. nasutus*; he thus differs from T. Scott, who regards it merely as a variety of the latter species.

Length of Day and Plant Growth.—Great activity is evinced in this field of physiological research, in which the literature was recently reviewed for English workers by Redington (NATURE, July 20, 1929, p. 108). In the *Biologisches Centralblatt*, vol. 49, pp. 513-543, Prof. Maximow, of the Institute of Applied Botany, Leningrad, gives a further account of his experiments in this field. He regards the attack upon the physiological effects of the length of the period of illumination as just beginning, and anticipates that the results of such investigations may be of great value in throwing light upon the transition from the vegetative to reproductive phase in plants. At the Royal Horticultural Society's gardens and laboratories at Wisley, Mr. M. A. H. Tincker continues the experiments he commenced at Aberystwyth upon the same problem. He gives a report of the progress of this work in the *Journal of the Royal Horticultural Society*, vol. 54, part 2, September 1929.

Forests and Rainfall.—The influence of forests on climate and water supply in Kenya is the subject of a pamphlet by Mr. J. W. Nicholson (*Pamphlets*, No. 2, Forest Department, Nairobi). Mr. Nicholson discusses first the general problems of forest and rainfall, and refutes the view that forests can have little influence in promoting rain. Unfortunately, there are few statistics on which to base arguments, and most of the discussion on this problem rests on a weak foundation. Mr. Nicholson is, however, convinced, even though he does not always carry conviction to his readers, that forest growth in East Africa has a considerable influence on precipitation. He believes that in favourable circumstances, mountain forests can induce dew on deposition from mist up to at least 25 per cent of the total annual rainfall. Monsoon rain is increased by forests to the extent of about 3 per cent. Cyclonic rain is not affected, but this type of rain does not occur in Kenya. On the other hand, he is convinced that convectional rain is greatly increased by the presence of forests. In discussing the relation of forests to the flow of streams, Mr. Nicholson does not agree that the retention of forests has much effect on the water capacity of the red clays of volcanic origin which cover considerable areas. They are of great depths, and though the surface layers may lose in fertility, the water flow to the streams remains fairly constant when the forests are removed. It is rather for their effect on increasing rainfall that he would preserve the forests.

Contributions to Mycology.—Vol. 14, Pts. 3 and 4 of the *Transactions of the British Mycological Society*, contains a number of contributions of varied and often general interest. These include the address of the president for 1928, Dame Helen Gwynne-Vaughan, given at the Littlehampton foray, upon "Problems of Development in the Fungi". The relations of the fungi with other groups are considered, as also such general problems as alternation of generations and heterothallism in the group. Mr. Chippendale discusses the behaviour in culture of a fungus parasitic upon cotton (*Ascochyta Gossypii.*). The causal organism of a leaf rot of the carnation (*Heteropatella Dianthii*) is described by Mr. Buddin and Miss Wakefield, and of a leaf-spot of *Arctostaphylos Manzanita* (*Pleospora herbarum*) by Messrs. Briant and Martyn. Miss Cayley has some very interesting observations upon the life cycle of the Mycetozoan genus *Didymium*, several species having been successfully reared in culture upon synthetic solid media. The conjugation of the motile (swarm-spore) gametes has been followed under the microscope; in some cases these gametes have arisen in monosporous cultures, so that an earlier statement to the effect that the spores were unisexual are not confirmed. Mr. Mitra describes a *Phytophthora* disease of cotton seedlings and fruit-rot of guava, whilst Mr. Ashby continues his interesting observations upon the stimulation of oospore production in pure strains of this fungus genus, even when homothallic, by pairing them in culture with some entirely different species. Mr. Corner has two papers upon the development of the ascothecium and ascocarp in the Discomycetes, a contribution to a much neglected field of fungus morphology. Mr. Cartwright has a note upon the unusual appearance of two wood-inhabiting fungi, *Lenzites* and a *Pholiota*, when grown in pure culture.

Kelvin Effect at Low Temperatures.—*Communication* No. 196a from the University of Leyden gives an account of the measurements of the Kelvin effects at temperatures down to that of liquid hydrogen in pure copper, copper alloy with 0·37 per cent gold, and silver alloy with the same amount of gold, made by Messrs. G. Borelius, W. H. Keesom, and C. H. Johansson. The wires were about a millimetre in diameter and were attached to a copper block which was cooled by liquid hydrogen. The change of temperature at the middle of the wire on reversing a current of 7·14 amp. through it was measured by a platinum resistance thermometer wound round the wire. The direct measurements were checked by measurements of the electromotive forces in thermo-circuits of the copper-gold alloy with lead, copper, and the silver-gold alloy. At room temperature the Kelvin effects are all positive and decrease as the temperature decreases; in copper, very quickly, so that at - 140° C. it is zero and becomes negative, reaches its greatest negative value at - 170° C. and then rises rapidly. In the copper-gold alloy it reaches a minimum at - 120° C., then a maximum at - 230° C. In the silver-gold alloy it has a minimum value nearly zero at - 180° C. In no case does the effect appear to approach zero as the absolute zero of temperature is approached, which it should do according to the Nernst heat theorem.

High Frequency Quartz Crystal Oscillators.—Everyone who has used a radio receiver for broadcast reception knows that the frequency of the carrier wave emitted by the transmitting station must be kept rigorously constant if interference between it and other stations is to be prevented. A very desirable transmitting circuit from the point of view of simplicity is to use a very selective one, that is, one which only emits appreciable radiation at a definite frequency. This is the circuit commonly used, and its working depends on resonance between a condenser and an inductive coil. Mechanical systems, however, can now be used with much higher selectivity and with a great increase of the frequency stability. In the *Bell Laboratories Record* for October, F. R. Lack gives an instructive account of modern high frequency quartz-crystal oscillators. He points out that any mechanical system of three dimensions possesses a large number of degrees of freedom. The crystalline nature of quartz, also, complicates the nature of its vibrations. The elastic constant in a given direction with respect to the axes of the crystal varies with the direction. As a result, in practice, a quartz plate has a large number of possible modes of vibration, some of them differing only by a few hundred cycles. It has been noticed that a change of temperature or a slight variation of the circuit to which the crystal is attached sometimes causes the crystal to jump from one of these modes of vibration to another. These difficulties have now been practically overcome, and crystals are being sold on a commercial basis. The vibrations utilised are those which take place in the direction of the thickness of the plate. The temperature coefficient of this type of vibration is ninety cycles in a million per degree Centigrade for crystals designed for frequencies of two million cycles per second. As telephone and radio requirements are becoming more rigorous every day, we expect that the use of crystal oscillators will rapidly increase.

Radio Time Signals.—Mr. A. R. Hinks has written an excellent pamphlet describing wireless time signals, the third edition of which has just been published by the Royal Geographical Society. It is primarily intended for the use of surveyors, who as a rule are not trained radio operators, but nevertheless must know how to receive the time signals transmitted from many high-powered stations for their benefit. The methods of signalling in 1925 were very varied but now they are becoming standardised. The first signals sent from the Eiffel Tower were mainly sent by hand, but the actual time signals were sent by the observatory clock. The signals were next made entirely automatic, the contact maker being synchronised with the observatory clock. The international system with the familiar six dots of the broadcasting time signal is now very commonly used. The standard rhythmic system, suggested originally by the Royal Geographical Society, was adopted by the International Union of Astronomy and Astrophysics and brought into use in January 1926. The accuracy of these time signals depends on the accuracy of the controlling clock and on the constancy of the lag introduced by the relays in the circuit between the clock and the transmitting apparatus. In winter, in the principal time-keeping observatories, Greenwich, Edinburgh, Paris, Hamburg, and Washington, there may be periods of a week or longer without seeing a star. Hence there may be an appreciable error in the time before it can be controlled by observation. Even when all precautions are taken by the surveyor, the error may be a tenth of a second. Very useful data are given which will interest everyone who has a good radio receiving set.

A Link between Strychnine and Brucine.—The close relation between the alkaloids strychnine and brucine has long been recognised. It is known that the latter contains merely two methoxyl groups more than the former, but no definite experimental demonstration of the relationship of the substances has hitherto been available. A few months ago the degradation of brucine by treatment with chromic acid was described by Wieland and Münster, who obtained two acids of the formulæ $C_{16}H_{20}O_4N_2$ and $C_{17}H_{22}O_6N_2$ respectively, but were unable to obtain a similar product from strychnine. The work has now been completed by Hermann Leuchs, who has long studied in this field, and who, with F. Kröhnke, describes in the September number of the *Berichte* (vol. 62, p. 2176) the degradation of diaminostrychnine. This substance, which is obtained by treating strychnine with concentrated nitric acid and reducing the product with stannous chloride, is easily oxidised by chromic acid, and gives rise to an acid which is completely identical with the second of the above-mentioned acids prepared from brucine. This acid can thus be considered as an experimental link between the derivatives of the two alkaloids.

Adsorption of Gases.—The *Journal of the American Chemical Society* for September contains an interesting paper by Prof. K. F. Herzfeld on the subject of adsorption of gases on solids, with special reference to the theory of catalysis. Previous workers have concluded that, although unimolecular film formation is part of the mechanism of the processes, there are present ‘ active spots ’ on the surfaces, perhaps places where metal (or other) atoms are raised above the rest of the surface, and thus in a position where their valency forces are less occupied with other atoms. In this way the decrease of heat of adsorption with increasing amount of gas adsorbed can be explained, since these ‘ active spots ’ would be the first to be covered. Herzfeld points out, however, that the reverse effect is also known, namely, increase of heat of adsorption with amount of gas adsorbed, and he gives a detailed analysis of the effect for the case of the adsorption of a gas without permanent dipoles on the surface of a solid composed of oppositely charged ions, assuming that the effects will be similar on metals. The abnormal result would then follow from the interaction of dipoles induced in neighbouring molecules by electric forces. “ The best explanation seems to be the formation of groups of adsorbed molecules sticking together ”. Some assumptions made by Taylor and his associates in explaining adsorption catalysis are carefully considered and shown to lead to difficulties.

The Cult of the Sun.

AT a meeting of the Royal Anthropological Institute on Nov. 5, Mrs. Zelia Nuttall read a paper on "The Cult of the Sun at the Zenith in Ancient America".

Attention was first directed to the important fact that all the ancient centres of civilisation in America are situated within the tropical zone. In this the sun passes through the zenith of each latitude twice a year at noon, excepting at the tropical lines, which it approaches very slowly, and passes through the zenith at noon for 10 or 12 consecutive days at the solstices, appearing to linger there before slowly moving away.

When the sun passes the zenith, vertical objects, of course, cast no shadow. The high temperature caused by the vertical rays over a particular area causes an indraught producing an ascending current carrying up the warm moist air which, condensed in the higher regions of the atmosphere, falls as rain. It is a law of Nature that, subject to modifications according to situation near sea or mountain ranges, the rainy season of any place begins almost, if not immediately, after the sun has reached its zenith.

Authentic, documentary, and historical evidence presented establishes that throughout tropical America this phenomenon was observed by means of gnomons ranging from staffs, high poles, plain or carved columns and stelæ, conical structures and altars, and finally temples situated on high substructures. The ancient sun priests dated the commencement of the year from the moment the gnomon cast no shadow, and the phenomenon was interpreted as a 'descent' of the sun, to which prayers were addressed for rain which, of course, were effective.

A number of peculiar structures with vertical shafts have been found in temples, and also below ground, and it is obvious that such would have afforded a perfect means of registering not only the sun at the zenith, when its rays would fall into the chamber, but also the culmination of the moon and other celestial bodies, in particular of the Pleiades in November, which heralded the dry season and gave the signal for the lighting of the bonfires which were kept burning day and night in the temple courtyards for public convenience during the dry and cold season.

The native representations in painting and sculpture show the sun god descending head-foremost in human form, or as a bird or a combination of both, associated with the serpent, the symbol of rain. A head in a solar disc or a winged head were also employed as symbols, and the sun god armed, seated in the centre of a solar disc, is another common form.

Mention was made of the interesting fact that, at Mrs. Nuttall's suggestion, the observation of the shadowless pole has been officially revived as a school festival in Mexico as an educational factor and a link with the past. This year, for the first time since 1519, it was celebrated in a public square, witnessed by thousands of school children, some of whom danced and sang in the Aztec language in native costume to the accompaniment of drums and flutes of ancient form.

In conclusion, it was pointed out that the northernmost great ruins in Mexico, those of the Guinada in the State of Zacatecas, are situated on the Tropic of Cancer, where the sun would appear to make a prolonged annual visit, and that in precisely the same latitude in Africa lie the ruins of Kalahshu, and not far to the south of Der, the ancient name of which was "the city of the sun". The ruins of Zimbabwe are within three degrees of latitude to the north of the Tropic of Capricorn, and their conical structure and a chamber with a vertical shaft appear to testify that in the Old, as in the New World, the inhabitants of the intertropical region observed and celebrated the passage of the sun through the zenith which was followed by rain.

The Storage of Food.

THE Report of the Food Investigation Board for 1928[1] again reveals the wide scope of the researches on the preservation and storage of food carried out under its auspices. During the year, Sir William Hardy retired from the chairmanship and was succeeded by Sir Joseph Broodbank: and Dr. F. F. Blackman and Dr. J. B. Orr succeeded Sir Richard Threlfall and the late Prof. T. B. Wood as members. The extension of the Low Temperature Research Station at Cambridge was well advanced at the end of the year, and the new fruit storage research station at East Malling had been commenced: it was also decided to set up a fish research station at Aberdeen. On the other hand, work on fish by-products was discontinued.

CONDITIONING OF BEEF.

An important research on the changes undergone by beef during storage and its effects upon the palatability and flavour of the meat has been carried out by T. Moran and E. C. Smith and published as a special report to the Board.[2] The following general procedure is recommended: after killing, the carcase should be carefully dressed and cooled for 1-2 days at 31°-33° F.; the meat is then hung as sides or quarters at 36°-38° F. for 10-12 days and finally stored for the 24 hours before sale at room temperature or at 40°-45° F. It is also necessary to rest the animal before slaughter if good quality meat is to be obtained.

The first change after death is the onset of rigor mortis, which consists of a gelation of the muscle plasma, causing hardening and loss of irritability, and a production of acid which causes contraction of the muscle, increase in opacity, and later the breakdown of the protein gel. In experiments on the rate of cooling of carcases, it was found that the temperature in the muscles increased for the first few hours after death, partly due to the conversion of glycogen into lactic acid and partly due to the changes in the physical state of the proteins. The later stage of resolution of rigor is relatively slow: it is brought about by autolysis, by the acidity of the tissues, and by bacterial action, and can be controlled to a considerable extent by the conditions of storage.

In following the changes in detail, it is necessary to consider separately each tissue of which the meat is composed. The state of the superficial connective tissue is largely responsible for the appearance of the meat: it readily takes up 80-100 per cent of its weight of water, and becomes white and opaque; this may occur from excessive swabbing on cleaning the carcase or from sweating on removal from cold store. On

[1] Department of Scientific and Industrial Research. Report of the Food Investigation Board for the year 1928. Pp. vi+110. (London: H.M. Stationery Office, 1929.) 3s. 6d. net.

[2] Department of Scientific and Industrial Research: Food Investigation. Special Report No. 36: Post-mortem Changes in Animal Tissues—The Conditioning or Ripening of Beef. By T. Moran and E. C. Smith. Pp. vii+64+8 plates. (London: H.M. Stationery Office, 1929.) 2s. net.

drying, the tissue loses its excess water and becomes translucent again ; but if frozen whilst swollen, the fibres become broken up and disorganised.

The fat becomes rancid on prolonged storage : the change can be followed by estimating the increase in free acids and the decrease in the iodine number. The state of the fat determines the period of storage, since the slightest taint of rancidity is undesirable, and this develops whilst the lean part of the meat is still improving in flavour.

Little alteration occurs in the proteins during storage after the resolution of rigor : in a short period of hanging, autolysis is negligible, there is no increase in the water which can be expressed from the muscle, and, except on exposed surfaces where methæmoglobin may be found, no change in the pigment.

As regards the carbohydrates, the effective changes are over within 3 days of slaughter : the lactic acid reaches its maximum of about 0·8 per cent and then remains unaltered throughout storage.

With ordinary cleanliness, bacterial contamination of the carcase is only slight, and experiment showed that increase in the bacterial content of meat hung for 17 days at 41° F. is negligible.

The experiments on the palatability of the stored beef were carried out at the Household Arts Department, King's College for Women, London, and at Messrs. J. Lyons and Co.'s laboratories. They showed that conditioning effects a marked improvement in palatability, particularly in respect of tenderness, but also of juiciness and texture, without any change in flavour. The improvement is more marked with coarse than with prime joints. A few experiments also indicated that freezing beef has no marked deleterious effect on its palatability.

Apart from the scientific aspects of the improvement of the meat supply, the demand of the public for good meat is an important factor to be considered, and it is to be hoped that the experimental grading and marking scheme for home-killed beef [3] will stimulate this demand by giving purchasers confidence that they can obtain exactly what they require.

Fruit and Vegetables.

The chemical changes occurring in apples stored at 12° and 1° C. have been further studied by D. Haynes and H. K. Archbold. The rate of loss of respirable material, sugar, acid, and residue (cell wall material) per unit of nitrogen (protoplasm) has been found to be characteristic of the variety. Storage life may be roughly divided into three periods : in the first, the starch is hydrolysed with a concomitant rise in sugar ; in the second, at 1° C., the total sugar and sucrose decrease, but the reducing sugar rises slowly to a maximum ; in other words, the rate of inversion of sucrose is greater than the rate of consumption of its products ; in the third, at 1° C., internal breakdown has set in and the rate of loss of sugar is increased ; at this point the sucrose has all been inverted and the stable reducing sugars stored in the vacuole are oxidised. Throughout, acid is lost, the rate in the first and third periods being faster than in the second. At 12° C. internal breakdown does not occur but is replaced by senescence, which is observed at an earlier period of storage life and is characterised by very similar changes in the constituents of the fruit.

Fungal invasion of stored apples has been studied by A. S. Horne: a close relationship between the chemical composition of the fruit and susceptibility to invasion has been found ; thus decrease in the amount of acid is associated with an increase in the rate of invasion. The relationship between growth of fungi and the environment, especially the humidity, has also been studied by R. G. Tomkins.

The possibility of the cold storage of vegetables has been investigated by J. Barker : the commoner vegetables can be stored for a few weeks at 45° or 33° F. The lower temperature is the more satisfactory, except for potatoes, which sweeten near the freezing-point. Even lower temperatures, 26° and 29° F., at which partial freezing occurs, are satisfactory for cabbages, cauliflowers, or sprouts, but not for tomatoes, cucumbers, or lettuces. Preliminary experiments on the rate of deterioration after removal from cold store indicated that 33° F. was more suitable than 45° F., except for tomatoes.

These excerpts must suffice to indicate the nature of some of the work which has been carried out under the direction of the Board. Among other subjects dealt with are corrosion of metal food-containers, with the production of hydrogen and perforation of the can, the transport of butter in insulated vans, and the freezing of fish on board the trawler so that it can be kept for a longer time and landed in a fresher condition. The report also refers to work on the control of temperature and humidity and on methods of refrigeration.

[3] Home-killed Beef: Experimental Grading and Marking Scheme. Ministry of Agriculture and Fisheries. Marketing Leaflet, Nos. 13 and 13*a*.

Nickel in Engineering.

In a lecture on "Nickel and its Uses in Engineering", delivered before the Junior Institution of Engineers on Nov. 15, Mr. W. T. Griffiths stated that, prior to the War, 65 per cent of the world's production of nickel was utilised in the manufacture of nickel steel for armament purposes ; after the Armistice, production dropped to the level of the years 1890–91.

New uses for nickel have now increased the consumption to as high a figure as any attained during the War. A considerable portion of the output is used, on account of its high melting-point, in the radio electrical industry for parts of wireless valves ; it is also used for the electrodes of sparking plugs. In chemical engineering much use is made of it on account of its ability to withstand alkaline reagents. In mechanical engineering it is largely used by means of electro deposition for building up worn parts of mechanisms, but its principal uses are found when alloyed with other metals ; for example, in steels it increases toughness, and in conjunction with heat treatment much improves the homogeneity of castings; in case-hardened articles it increases the penetration of the hardening material, and in many cases eliminates a preliminary heating and quenching ; in conjunction with chromium and molybdenum, large forgings can be made as the elastic limit of the material is much improved. In Canada, nickel alloy steel is used in casting the bar framing of locomotives and even in boiler parts including plates, firebox and tubes being made of an alloy steel containing 2 per cent of nickel, thus enabling the boiler pressure to be increased by some 37 per cent without increasing the weight of the engine.

When alloyed with iron, nickel has the property when present to the extent of about 25 per cent of destroying the magnetic properties of iron, but a higher percentage of nickel restores these properties, and the Western Electric Co. of America has established that after heat treatment of high content nickel-iron alloys, the magnetic qualities are 10-13 times better than the best soft iron ; it also has much effect in diminishing the hysteresis loss. These properties are of much use in submarine cables where great permeability is desirable to ensure quick working. The alloy is insulated from but wound round the copper conductor and prevents the interference of stray currents. An alloy of 35 per cent nickel, 35 per cent cobalt and iron, known as perminvar, shows great constancy of permeability. In heat-resisting steels, it prevents corrosion of the steel up to temperatures of 600°-700° C. Nickel chromium alloys are now largely used for electrical heating purposes, ribbons of the alloy arranged along the top and sides providing the heating elements in large annealing furnaces.

Nickel alloyed with copper increases the tensile strength of the latter from 21 tons to 45 tons per square inch. It is now greatly used for condenser tubes, these as compared with brass having a long life without corrosion.

In the discussion following the paper, it was stated that nearly all the nickel used in the world comes from within the Empire, Canada producing 90 per cent of it; there are also small deposits in New Caledonia.

University and Educational Intelligence.

Birmingham.—On Nov. 13 the new Mining Machinery Laboratory was opened by Mr. Evan Williams, president of the Mining Association of Great Britain. The object of the laboratory is to enable students of mining to get first-hand knowledge of the construction and mechanism of the latest coal-mining machinery, which will be supplementary to the knowledge of the operation of coal-cutting and conveying, which can only be learnt underground. The Miners' Welfare Fund has found the money for the building, and the machinery for equipment has been presented by the manufacturers themselves, no fewer than twenty-two firms having contributed of their products. The opening of this laboratory marks a further step in the policy of the Mining Department, which is to help the coal industry to regain its prosperity by providing it with trained public school and university men who, after acquiring experience underground, should be capable of contributing to the solution of some of the many problems with which the industry is confronted.

Cambridge.—Mr. D. Portway, St. Catharine's College, has been appointed University lecturer, and Mr. G. S. Gough, Pembroke College, University demonstrator in the Faculty of Engineering.

Dr. E. K. Rideal has been appointed a member of the Board of Research Studies.

Manchester.—Prof. F. E. Weiss will retire at the end of the present session from the George Harrison chair of botany and the directorship of the Botanical Laboratory. He has held these appointments since 1892.

It it announced in the Report of the governing body of the School of Oriental Studies of the University of London that a lectureship in Iranian studies has been founded in the School. The funds for the foundation have been provided for a period of five years by the Parsee community of Bombay. This is not the first occasion on which humane and historical studies in Great Britain have been indebted to the public spirit and munificence of the Parsee community in India, and there can be little doubt that when the first period of five years has elapsed it will once more come forward to meet an increasing need. For, as the report points out, this chair is the only provision in Britain for this important branch of Oriental studies. In fact, the great increase in the study of Sanskrit and Indian history has necessitated the institution of two new lectureships in these departments.

Calendar of Patent Records.

November 23, 1848.—The idea of perforating sheets of postage stamps was due to Henry Archer, who devised a machine for "cutting or stamping around the margin of every stamp a consecutive series of holes whereby the tearing up of the sheet will be greatly facilitated," and obtained an English patent for his invention on Nov. 23, 1848.

November 24, 1854.—In a patent granted to him on Nov. 24, 1854, Sir Henry Bessemer proposed to give rotation to a projectile when fired from a smooth-bore gun by allowing a portion of the powder gas to escape through passages formed in the projectile and terminating in the direction of a tangent to its circumference. The tangential emission of gas would then act as a turbine and produce a rapid rotatory motion of the projectile. The British military authorities refused to undertake tests of the invention, but Bessemer carried out successful experiments in his own grounds near Highgate and afterwards at Vincennes before the Emperor Napoleon III. It was the necessity of increasing the strength of the guns to enable them to withstand the resulting pressures that led Bessemer to the serious study of the metallurgy of iron.

November 24, 1874.—The earliest proposal for a barbed-wire fencing was made in the United States in 1867, but the most important patent was that granted to Joseph F. Glidden on Nov. 24, 1874, on an application made on October of the previous year. Glidden's application was challenged by Jacob Haish, another prominent inventor of a barbed wire, but the United States patent office decided in favour of Glidden, and it is mainly on his invention that the industry was established. Patent litigation between the rival interests was continuous from 1874 until 1892.

November 25, 1802.—William Dobson was granted a patent on Nov. 25, 1802, for his "new invented method never before applied for that purpose of chasing away flies and venemous insects, and calculated to promote the free circulation of air in rooms". The invention comprised a clockwork-driven fan mounted on a telescopic standard or pendant. The 'Zephyr', as it was called, was adopted by many large houses in Great Britain and abroad.

November 26, 1822.—Joseph Egg, a London gunmaker, who, on Nov. 26, 1822, was granted a patent for improvements in fire-arms "upon the self-priming and detonating principle", is one of the claimants to the invention of the copper percussion-cap. He appears to have been the first to manufacture such caps, but it was stated a few years later that he obtained the idea of the cap indirectly from Joshua Shaw, who probably has a better right to be called the actual inventor.

November 29, 1879.—The early multiple switchboards for telephone exchanges did not completely fulfil their function, because satisfactory means had not been devised whereby any operator could instantly ascertain whether a particular subscriber's line was already engaged by another operator. The first to incorporate a practical 'test' apparatus of this kind in a telephone switchboard was the American, C. E. Scribner, who was granted a British patent on Nov. 29, 1879, for his invention. The earliest known proposal for a switchboard for the purpose of intercommunication between individual subscribers at their own request was made in connexion with the telegraph system, and was patented by François Dumont in France in 1850, also in the month of November, and in England a few months later. A few installations of this character came into use.

Societies and Academies.

London.

Royal Society, Nov. 14.—V. Henri and O. R. Howell: The structure and activation of the molecule of phosgene. An analysis of the ultra-violet absorption spectrum of phosgene vapour. The spectrum, about 270 bands between 3050 A. and 2380 A., has been photographed at pressures from 0·1 mm. up to 680 mm. and analysed. The absorption region is therefore the same as for all substances containing the CO group, but whereas with aldehydes and ketones the absorption reaches a maximum at about 2800 A., with phosgene it increases continuously towards the ultra-violet. The spectrum is purely vibrational. The bands consist of doublets with a separation of 0·5-1 A., and of singlets distributed at regular intervals in the spectrum. As an aid to elucidating the ultra-violet spectrum, the Raman spectrum of phosgene was also obtained.—T. M. Lowry and C. B. Allsopp: A photographic method of measuring refractive indices. A film of liquid is formed between the half-platinised plates of a quartz etalon, illuminated with multi-chromatic light from a metallic arc, and the interference bands formed in the film focused on the slit of a spectrograph. After calibrating the instrument with an air film, the refractive index of the liquid is deduced from the number of ripples between two fixed points on the slit of the spectrograph.—C. P. Snow and E. K. Rideal: Infra-red investigations of molecular structure (3 and 4). The vibration-rotation band ($n''=\frac{1}{2}\longrightarrow n'=\frac{3}{2}$) of CO has been resolved completely. The general character of vibration-rotation bands carried by ^1S molecules is discussed, and the CO bands are shown to be consistent with the scheme. A theoretical discussion includes constants of potential functions and description of band lines.—P. M. S. Blackett, P. S. H. Henry, and E. K. Rideal: A flow method for comparing the specific heats of gases. A slow stream of gas passes through an electrically heated iron tube, to which are attached constantan wires, in such a way as to measure temperature difference between two points symmetrically placed on tube. Temperature distribution along the tube alters slightly, and, under certain conditions, measured temperature change is a direct measure of specific heat of gas.—J. H. Brinkworth: On the temperature variation of the specific heats of hydrogen and nitrogen. Specific heats of nitrogen can be calculated to an accuracy of 1 in 500, at 60°-1200° K., using Callendar's characteristic gas equation. With a modified Planck-Einstein formula for rotational specific heat, hydrogen values agree extremely well with experiment below 600° K.; at 1000° K. they are high, but there is excellent agreement at 1200°-1600° K. Moments of inertia of molecules of hydrogen and nitrogen are deduced.—R. W. Lunt and M. A. Govinda Rau: The variation of the dielectric constants of some organic liquids with frequency in the range 1 to 10^3 kilocycles. There is no variation for benzene, ether, or chloroform, but a slight increase for methylated ether, ethyl alcohol, acetone, aniline, and nitrobenzene takes place in the range 10^2-10^3 kc. In this range the conductivity of aniline diminishes rapidly as the frequency is increased, that of nitrobenzene diminishes slightly, whilst that of ethyl alcohol and of acetone does not vary.—J. A. Hall: The international temperature scale between 0° and 100° C. An extensive intercomparison between the platinum-resistance thermometer and a number of mercury in *verre dur* thermometers, standardised by the Bureau International des Poids et Mesures, shows that the change from the latter to the former as the standard of the National Physical Laboratory, will not alter the temperature scale used by that institution by more than 0·002° C. between 0° and 50° C. or 0·005° C. between 50° and 100° C. Differences between scale defined by platinum thermometer and thermodynamic scale probably do not exceed a few thousandths of a degree between 0° and 50° C., or 0·01° C. between 50° and 100° C.—D. M. Murray-Rust and Sir Harold Hartley: The dissociation of acids in methyl and ethyl alcohol. In methyl and ethyl alcohols, HCl, $HClO_4$, $HClO_3$, $HEtSO_4$, $HSO_3C_6H_5$ are strong electrolytes, while HNO_3, HCNS, HIO_3 are weak acids. From measurements with hydrogen chloride, the mobility of the hydrion is calculated to be 142 in methyl, and 59·5 in ethyl alcohol. Addition of small quantities of water to solutions of acids in alcohol causes large decrease of conductivity of the strong acids and correspondingly large increase in case of weak acids, and can be used as a qualitative test for the two classes.—K. S. Krishnan: The influence of molecular form and anisotropy on the refractivity and dielectric behaviour of liquids. The theory of the optical and electrical properties of liquids outlined by Raman and Krishnan is applied to the case of benzene for which the necessary data are available. The change in the Lorentz refraction 'constant' in passing from vapour to liquid, and the effect of temperature and pressure variations on the 'constant' are successfully evaluated numerically. The application of the theory to the dielectric behaviour of liquid benzene is equally successful.

Linnean Society, Nov. 7.—Dr. Hugh Scott: A natural history excursion into Basutoland. Deforestation and destruction of big game have been extensive. Almost the only native 'timber' seen was scrub composed of a Rosaceous bush, *Leucosidea sericea*, 5-15 ft. high. All arable land is devoted to cultivation of mealies (maize) and Kafir corn (*Sorghum*), and the grassy slopes are stocked with horses and cattle. Entomological collecting resolves itself largely into 'sweeping' grass and flowers, searching under stones and working the low dense bush of kloofs. The insects obtained, about a thousand specimens, are being dealt with at the British Museum. A species of cockroach was observed to display maternal care for its young, a fact of considerable biological interest. —G. E. Nicholls: A new Syncaridan from the west coast of Tasmania. This small freshwater crustacean was first taken by the author in February 1928 in a sphagnum-choked ditch near Queenstown. It is the third member of the sub-order Anaspidacea to be discovered in Tasmania, and seems most closely related to *Koonunga cursor*, at present known only from the Australian mainland. It is less than one-third of an inch in length, colourless and almost transparent. The mature animal is conspicuous by its golden or orange-coloured gonads, and in these specimens a chocolate-brown pigment is developed irregularly upon the dorsal surface.

Edinburgh.

Royal Society, Nov. 4.—Frances M. Ballantyne: Notes on the development of *Callichthys littoralis*. A description of the embryonic and larval stages of this armoured Siluroid. After giving a general account of the ontogeny of the fish, the development and the adult form of the skull and chondrocranium, of the fins and external skeleton, and of the various organs, are described in some detail. Particular attention is directed to the air-sacs at either side of the head, and their relationship with the otocyst, and it is shown that they develop from a transient air-bladder.

These very specialised fish have some primitive characters reminiscent of *Polypterus* and the Dipnoi. The resemblance to *Polypterus* is specially marked in the development of the paired fins and in some of the modifications of the venous blood-system, while another primitive feature is shown in the platybasic chondrocranium where the trabeculæ are continuous with the parachordals. The facts of development, however, clearly show that the Siluridæ are rightly placed among the Teleostei.—A. W. Greenwood: Some observations on the thymus gland in the fowl. The examination of thymus weights in normal, castrated, and gonad engrafted fowls showed that in normal adult fowls the thymus is larger in the male than in the female. Castration and ovariotomy delay or decrease the rate of thymus involution. Whereas successful implantation of testis into complete males has no effect on the thymus, successful implantation of ovary causes a degree of thymus involution comparable with that in the female.—B. P. Wiesner: On the mechanism of the diphasic sex cycle. The periodic appearance of the œstrous cycle is due to periodic secretion of the ovary. There exists periods of refractory behaviour in the ovarian response to anterior lobe. The anterior lobe itself works periodically in two phases: the first phase incites the first phase of ovarian secretion (œstrous hormone) through an œstrogenic substance (Rho 1); the second phase incites beta production in the ovary through a 'kuogenic' substance (Rho 2). Methods are described for the separation of Rho 2, which is more resistant to heat than Rho 1, and the specific test for it (mucification) is discussed.—L. Mirskaja: On the presence of a kuogenic substance in the mouse placenta. The placenta, when implanted in the immature mouse, creates conditions of pseudopregnancy, and never induces œstrus. Since it is without effect in the ovariectomised female, it is assumed that it contains a kuogenic substance equivalent to Rho 2 from the anterior lobe.—A. C. Fraser and B. P. Wiesner: Variations of the rest metabolism of the rat in relation to the sex cycle. Varies considerably in relation to the œstrous cycle. A relatively high maximum is reached shortly after heat.—H. W. Turnbull and J. Williamson: Further invariant theory of two quadratics in n variables. The paper materially simplifies an original argument used twenty years ago, which was the basis of a paper published by the Society in 1925.

Paris.

Academy of Sciences, Oct. 14.—Marin Molliard: Two new examples of morphological characters depending upon external conditions. The abnormal development of hair in a pea pod can be produced by partially exposing the internal epidermis of the pod to the air. The second case was the experimental production of red stripes in the petals of the white opium poppy by prematurely opening the buds and separating the two sepals.—Léon Guillet and Ballay: The corrosion of aluminium alloys in superheated steam. The experiments were carried out on the purest aluminium obtainable (99·87 per cent), three samples of ordinary commercial aluminium, an alloy with 8 per cent copper, duralmin, and alpax. The purest metal was completely destroyed; alpax was the most resistant to the steam. It is probable that the corrosion in steam is a function, not only of the chemical composition, but also of the structure and previous thermal and mechanical treatment of the alloy.—Herbrand: The fundamental problem of mathematics.—J. A. Lappo-Danilevski. The generalisation of the formula of Jacobi concerning the determinant formed from solutions of a system of linear differential equations.—A. Andronow: The limit cycles of Poincaré and the theory of self-maintained oscillations.—A. Tsortsis: A method of integration of Monge's equations.—Victor Vâlcovici: The generalisation of the theorem of moments of quantities of motion.—N. Théodoresco: A formula generalising Cauchy's integral and on the equations of plane elasticity.—André Argand: Concerning the study of the plane irrotational movement of incompressible fluids in the steady state.—Marcel Prot: The calculation of railway sleepers of reinforced concrete.—William Loth: The magnetic guidance of airships; safety aerodromes. Description of improvements on the method described in 1921 and 1922 for guiding aeroplanes or airships to an aerodrome under conditions of bad visibility.—Maurice Lambrey: The absorption spectra of nitric oxide.—P. Chevenard: The limit of the solubility of copper in the reversible ferro-nickels. An application of the dilatometric method to the study of the diagram iron-γ-nickel-copper.—Paul Remy-Cennetè: The dissociation of calcium hydride, CaH_2. Previous work on this subject has given discordant results; some workers have found normal dissociation phenomena, others suppose that the hydride and the metal form a continuous series of solid solutions, and that the pressures found are a function of the calcium in excess. In the present experiments, the distillation of the calcium is prevented by enclosing it in a sealed iron tube, advantage being taken of the fact that at high temperatures iron allows hydrogen to pass through, but not calcium vapour. It has been established that the pressure is a function of the temperature only and is independent of the proportion of calcium present.—B. Bogitch: The oxidation and reduction of the iron silicates by gases. A blue silicate exists corresponding to a lower oxide of iron which alone is stable in the presence of metallic iron at high temperatures. This lower oxide is nearly always accompanied by FeO.—Maurice François: Study of the dissociation of the compounds $HgBr_2 . 2NH_3$ and $HgCl_2 . 2NH_3$. These compounds are molecular combinations analogous with Isambert's ammoniacal silver chloride.—A. Pereira Forjaz: Contribution to the study of the Müntz methods of nitrification. In the biochemistry of the fixation of atmospheric nitrogen it is possible that mineral catalysts may intervene; experiments with *Cytisus proliferus*, var. *palmensis* using a spectroscopic method showed that in this case the specific elements of biocatalysis were molybdenum, nickel, and cobalt.—L. Mercier: The chetotaxy of the wing of *Limosina pusilla*, from the point of view of secondary sexual characters.—Brocq-Rousseu, Mme. Z. Gruzewska, and G. Roussel: The influence of the ionic concentration of the medium on the activity of the amylase of horse serum. Whatever number of successive bleedings may be carried out, amylase and maltase are always found in the serum. Diagrams are given showing the relation between the sugar present and the number of bleedings.—Paul Génaud: The ion exchanges between yeast cells and solutions of lead nitrate.—A. Policard, S. Doubrow, and M. Boucharlat: The mechanism of pulmonary silicosis. The influence on cells cultivated *in vitro* of silica dusts arising from working on the rock in coal mines. Gye and Kettle, in their studies on silicosis, and Mavrogordato, in experiments on the effects of dust inhalation, have attributed this action to the slow solubility of silica in the slightly alkaline tissues. The experimental facts cited tend to confirm the view that regards the origin of the troubles of pulmonary silicosis as due to a slow toxic action of slowly dissolved silica.—Georges Blanc and J. Caminopetros: Some experimental data on the virus of dengue. The experiments described show that the virus of dengue and that of yellow fever are distinct.

VIENNA.

Academy of Sciences, July 11.—**E. Gebauer-Fülnegg and E. Riess**: The course of oxidation in aryl-sulpho-arylides.—**E. Reiss and R. Feiks**: The action of aromatic sulpho-chlorides on β-amino-anthraquinone.—**E. Blumenstock-Halward and E. Riess**: Note on trimercapto-β-naphthol.—**M. Samec**: Sulphurylisation of starch.—**E. Abel and E. Neusser**: The vapour pressure of nitrous acid.—**O. Redlich**: The molecular state of water.—**F. Böck and G. Lock**: The determination of hydroquinone and pyrocatechin in the presence of other phenols (1).—**K. Beaucourt**: The constituents of resin (1). The boswellinic acid from olibanum (incense resin).—**F. Pollak**: The kinetics of the reaction between bromic acid and hydrobromic acid.—**K. Schwarz**: A simple micro-method for determining molecular weights. Depends on isothermic distillation.—**G. Koller and E. Krakauer**: The constitution of cetraric acid, $C_{20}H_{18}O_9$, obtained from an Icelandic lichen.—**G. Koller and E. Strang**: Some derivatives of 6, 7-benzo-1, 8-naphthyridine.—**W. Leithe**: The natural rotation of polarised light by optically active bases (4). The rotation of some synthetic isoquinoline derivatives.—**H. Holter and H. Bretschneider**: Researches on the possibility of the formation of tetrazomethane, CN_4.—**G. Burger**: The separation of alkalis in minerals with the interferometer. A possible gravimetric determination of potassium and sodium by an optical method.—**A. Friedrich and A. Salzberger**: On lignin (5). The connexion between lignin and resin. The resin in spruce wood differs from the resin obtained from wounds of this tree, the resin extracted from the wood containing methoxyl groups. There is one sort of lignin dissolved in the wood-resin and another lignin in contact with cellulose.—**H. Mache**: Specific heat on the lines of equal internal energy and of equal heat content.—**J. Kisser**: Analysis of the results of chemical stimuli in seed germination. Preliminary inquiries with quickly germinating seeds. Access of oxygen is of great importance.—**J. Kisser and S. Possnig**: Researches on the influence of impeded and promoted oxygen respiration on seed germination and seed growth. Oxygen helps; the seed-coat of *Pisum* hinders access of oxygen, hydrogen peroxide penetrates the seed-shell.—**J. Kisser and R. Stasser**: Researches on the bending of roots and hypocotyls of shelled seeds of Leguminosæ. The seed-coat adheres to the radicle, hence removal of this part of the coat may injure the radicle.—**J. Kisser and R. Windischbauer**: Researches on the permeability of the seed coats of *Pisum sativum* for water and gases. Hydrogen peroxide delays the swelling, but stimulates germination. Weak solutions of sodium and manganese chlorides promote swelling of the seed-coat. Air-dry seed-coats permit the passage of gases with difficulty.—**S. Meyer**: Physical foundations for radium emanation therapy. Radium emanation absorbed by the human body is in preponderating measure lost again by breathing.—**E. Kara-Michailova and B. Karlik**: The relative brightness of scintillations of H-rays of different range. The α-particles lose energy in penetrating a crystal layer, and the brightness corresponds to the energy lost. Effects depend on the size of the crystals and the thickness of the zinc sulphide layer.—**K. Fritsch**: *Camelina rumelica*. A variable plant.—**E. Müller and W. Loerpabel**: The catalytic decomposition of aqueous solutions of formic acid by the platinum metals (4).—**R. Schumann**: Vectorial adjustment of a measured triangle.

Official Publications Received.

BRITISH.

Transactions of the Institution of Chemical Engineers. Vol. 6, 1928. Pp. 202. (London.)

Commonwealth of Australia: Bureau of Meteorology. Results of Rainfall Observations made in Western Australia, including all available Annual Rainfall Totals from 1374 Stations for all Years of Record up to 1927, with Maps and Diagrams; and Record of Notable Meteorological Events; also Appendices, presenting Monthly and Yearly Meteorological Elements of Perth, Broome and Kalgoorlie. Pp. xiv+387. (Melbourne: H. J. Green.)

Studies from the Connaught Laboratories, University of Toronto. Vol. 3, 1926–1928. Pp. vii+331. (Toronto: University of Toronto Press.)

Department of the Interior, Canada. Publications of the Dominion Observatory, Ottawa. Vol. 10: Bibliography of Seismology. No. 1, January, February, March 1929. By Ernest A. Hodgson. Pp. 17. (Ottawa: F. A. Acland.)

Records of the Geological Survey of India. Vol. 62, Part 2. Pp. 187-291+9 plates. (Calcutta: Government of India Central Publication Branch.) 2.12 rupees; 5s.

Proceedings of the Sixteenth Indian Science Congress, Madras, 1929. (Third Circuit.) Pp. xxxiv+474. (Calcutta: Asiatic Society of Bengal.)

Home Office. Report on Conferences between Employers, Operatives and Inspectors concerning Fencing of Machinery, First Aid and other Safeguards in Cotton Weaving Factories. By Eliot F. May. Pp. 21. (London: H.M. Stationery Office.) 3*d*. net.

FOREIGN.

University of California Publications in American Archaeology and Ethnology. Vol. 24, No. 2: Petroglyphs of California and adjoining States. By Julian H. Steward. Pp. 47-238+plates 22-94. 2.50 dollars. Vol. 24, No. 3: Yokuts and Western Mono Pottery-making. By A. H. Gayton. Pp. 239-252+plates 95-102. 40 cents. Vol. 25, No. 4: Archaeology of the Northern San Joaquin Valley. By W. Egbert Schenck and Elmer J. Dawson. Pp. 289-413+plates 74-102. 1.55 dollars. (Berkeley, Cal.: University of California Press; London: Cambridge University Press.)

Conseil International de Recherches, Union Géodésique et Géophysique Internationale: Section d'Océanographie. Bulletin N. 12: Bibliographie des Marées (1910–1927). By Prof. J. Proudman. Pp. 27. (Venezia.)

Recueil des Travaux Chimiques des Pays-Bas. Publié par la Société Chimique Néerlandaise. Tome 48, No. 9. Pp. 797-1074+ii. (Amsterdam: D. B. Centen.)

Publications de l'Observatoire Astronomique de l'Université de Belgrade. Tome 2: Annuaire pour l'an 1930. Rédigé par V. V. Michkovitch. Pp. 133. (Belgrade.)

CATALOGUES.

High-Tension Transformers for the Production of X-Rays. (Bulletin W.) Pp. 48. (London: Watson and Sons (Electro-Medical) Ltd.)

Chemische, chemisch-technische und physikalische Zeitschriften. (Jahrg. 8, Nr. 4, November.) Pp. 16. (Berlin: Verlag Chemie, G.m.b.H.)

Catalogue of Important, and in many cases, Rare Books in various Branches of Natural History. (No. 172.) Pp. 96. (London: Dulau and Co., Ltd.)

Medical Books, New and Second-hand. (Catalogue of Dept. No. 9, November.) Pp. 44. (London: W. and G. Foyle, Ltd.)

The Bureau of Information on Nickel. Nickel Steel, Series A, Paper No. 4: Breaking Records and Breaking Stresses; Nickel Alloy Steels in the *Golden Arrow*. Pp. 8. (London: The Mond Nickel Co., Ltd.)

Diary of Societies.

FRIDAY, NOVEMBER 22.

ASSOCIATION OF ECONOMIC BIOLOGISTS (in Botany Department, Imperial College of Science and Technology), at 2.30.—Research on Infestation of Stored Products: (*a*) Entomological—(i) Survey and Inspection Work, W. S. Thomson, (ii) Biological Work, G. V. B. Herford; (*b*) Mycological, R. H. Bunting.

ANDERSONIAN CHEMICAL SOCIETY (at Royal Technical College, Glasgow), at 3.15.—A. L. Parker: Artificial Silk.

PHYSICAL SOCIETY (at Imperial College of Science), at 5.—D. P. Dalzell: Heaviside's Operational Methods.—E. T. Hanson: The Dynamical Theory of Resonators.—E. C. Atkinson: Escapement Errors of Pendulum Clocks.

INSTITUTION OF ENGINEERING INSPECTION (at Royal Society of Arts), at 5.30.—T. W. Willis: Saws: Their Manufacture and some Hints on their Use.

BRITISH PSYCHOLOGICAL SOCIETY (Æsthetics Section) (at Bedford College), at 5.30.—J. M. Thorburn: Spengler's Æsthetic.

SOCIETY OF CHEMICAL INDUSTRY (Liverpool Section) (at Liverpool University), at 6.—H. W. Rowell: Commercial Synthetic Resin Products.

INSTITUTION OF MECHANICAL ENGINEERS (Informal Meeting), at 7.—J. S. Atkinson and others: The Utilisation of Low-Grade and Refuse Fuels, including Towns' Refuse.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—H. D. Bush: The Quick-Running Oil Engine applied to and used in Railway Service.

ROYAL SOCIETY OF MEDICINE (Epidemiology and Tropical Diseases Sections), at 8.—Discussion on Brucella Infections in Man and Animals. Openers: Dr. W. Dalrymple-Champneys (Epidemiology), Dr. J. T. Duncan (Tropical).

ROYAL AERONAUTICAL SOCIETY (Yeovil Branch) (at Yeovil).—Aero Wheels and Tyres.

SATURDAY, NOVEMBER 23.

BRITISH MYCOLOGICAL SOCIETY (at University College), at 11 A.M.—Prof. R. R. Gates and D. V. Daran: Zygospore Formation in *Mucors*.—Miss J. Grove: Growth Reactions of *Helotium scutula* Karst.—Dr. R. G. Tomkins: The Relation of Mould Growth to Humidity.—Dr. H. Wormald: Some Recent Observations on Brown Rot Diseases of Fruit Trees.—E. C. B. Wright: Sexual Reproduction in *Penicillium*.

MONDAY, NOVEMBER 25.

INSTITUTE OF ACTUARIES, at 5.—H. J. Tappenden: A Valuation of Non-Participating Policies without Classification.
INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting), at 7.—C. Wade and others: Discussion on Wooden Poles for Overhead Transmission Lines, and their Preservation.
INSTITUTION OF AUTOMOBILE ENGINEERS (Scottish Centre) (at Royal Technical College, Glasgow), at 7.30.—W. H. Goddard: The Mercédès-Benz Diesel Engine.
BRADFORD TEXTILE SOCIETY (at Midland Hotel, Bradford), at 7.30.—P. Morgan: Welsh Wools.
ROYAL SOCIETY OF ARTS, at 8.—Dr. E. G. Richardson: Wind Instruments from Musical and Scientific Aspects (Cantor Lectures) (II.).
ROYAL SOCIETY OF MEDICINE (Odontology Section), at 8.—J. H. Badcock: The Design of Partial Dentures Considered in Relation to the Health of the Oral Tissues.—F. St. J. Steadman: A Dentigerous Cyst in Connexion with a Supernumerary Incisor.—Dr. E. W. Fish: A Report on Dr. Gottlieb's Histological Study of the Results of Traumatic Occlusion.
MEDICAL SOCIETY OF LONDON, at 8.30.—Clinical Evening.

TUESDAY, NOVEMBER 26.

INSTITUTE OF MARINE ENGINEERS, at 6.30.—A. F. Evans: The Origin and Development of Heavy Oil Engines.
INSTITUTION OF ELECTRICAL ENGINEERS (East Midland Sub-Centre) (at University College, Nottingham), at 6.45.—E. H. Smythe and E. G. Weeks: Low-Temperature Carbonisation of Fuel, with Special Reference to its Combination with the Production of Electricity.
INSTITUTION OF ELECTRICAL ENGINEERS (North-Eastern Centre) (at Armstrong College, Newcastle-upon-Tyne), at 7.—Capt. P. P. Eckersley: Broadcasting by Electric Waves (Faraday Lecture).
INSTITUTION OF ELECTRICAL ENGINEERS (North Midland Centre) (at Hotel Metropole, Leeds), at 7.
INSTITUTION OF ELECTRICAL ENGINEERS (North-Western Centre) (at Engineers' Club, Manchester), at 7.—Lt.-Col. S. E. Monkhouse and L. C. Grant: Heating of Buildings Electrically by Means of Thermal Storage.
INSTITUTE OF METALS (Birmingham Local Section) (jointly with Birmingham Metallurgical Society and Staffordshire Iron and Steel Institute) (at Chamber of Commerce, Birmingham), at 7.—G. W. Woolliscroft: The Modern Development of the Steam Locomotive.
ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Scientific and Technical Group), at 7.—Dr. S. O. Rawling: How it works in Photography: A Chemist's Notions about Sensitivity (Lecture).
INSTITUTION OF AUTOMOBILE ENGINEERS (Western Graduates' Section) (at Works of Bristol Tramways and Carriage Company, Ltd., Brislington, Bristol), at 7.30.—E. W. Sisman: Braking Topics.
WEST KENT SCIENTIFIC SOCIETY (at Wesleyan Hall, Blackheath), at 8.30.

WEDNESDAY, NOVEMBER 27.

ROYAL SOCIETY OF MEDICINE (Comparative Medicine Section), at 5.—J. Menton and H. W. Steele Bodger: The Improvement in the Public Milk Supply: is Pasteurisation Necessary?
INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS (North-Western District) (at Manchester Town Hall), at 6.—Parliamentary Bill Proceedings.
INSTITUTION OF AUTOMOBILE ENGINEERS (Manchester Centre) (at Engineers' Club, Manchester), at 7.—F. R. Banks: The High-Speed, Compression-Ignition, Heavy-Oil Engine.
SOCIETY OF CHEMICAL INDUSTRY (Newcastle Section) (at Armstrong College, Newcastle-upon-Tyne), at 7.30.—W. S. Coates: Modern Boiler Practice (II.): Boiler Feed Water Conditioning.
TEXTILE INSTITUTE (Lancashire Section) (at Art School, Macclesfield), at 7.30.—A. J. Hall: The Physical and Chemical Properties of Cellulose in Relation to Technical Treatment of Cotton and Artificial Silk.
SOCIETY OF DYERS AND COLOURISTS (Midlands Section) (at Globe Hotel, Leicester) (jointly with Foreman Dyers' Guild), at 7.45.—F. Willis and W. A. Edwards: A Short Résumé of the Manufacture of Hosiery Goods with Special Reference to Difficulties met with in Dyeing and Finishing.
ROYAL SOCIETY OF ARTS, at 8.—C. N. Kemp: The Examination of Coal and Coke by X-Rays (Dr. Mann Lecture).
INSTITUTION OF CHEMICAL ENGINEERS (at Chemical Society), at 8.—J. Strachan: Production and Treatment of Cellulose in the Paper Industry.

THURSDAY, NOVEMBER 28.

IMPERIAL COLLEGE CHEMICAL SOCIETY (at Royal College of Science), at 5.—Prof. H. V. A. Briscoe: The Work of the Coke Research Committee (Lecture).
CHILD-STUDY SOCIETY (at Royal Sanitary Institute), at 6.—Miss Marion Richardson: The Teaching of Handwriting.
INSTITUTION OF ELECTRICAL ENGINEERS, at 6.—H. W. Taylor: Voltage Control of Large Alternators.
NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (at Newcastle-upon-Tyne), at 6.—G. S. Baker: Wake.
ROYAL AERONAUTICAL SOCIETY (at Royal Society of Arts), at 6.30.—Squadron Leader H. M. Probyn: Flying and Maintenance from the Owner's Point of View.
ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Kinematograph Group—Informal Meeting), at 7.—A. S. Newman: The Care and Upkeep of Amateur Kinema Apparatus.
INSTITUTION OF AUTOMOBILE ENGINEERS (Luton Graduates' Section) (at Royal Hotel, Luton), at 7.30.—S. W. Dixon: The Automobile Compression Ignition Engine.
INSTITUTION OF AUTOMOBILE ENGINEERS (Newcastle-upon-Tyne Centre) (at Y.M.C.A., Newcastle-upon-Tyne), at 8.—A. Healey: The Pneumatic Tyre in Heavy Transport.
MEDICO-LEGAL SOCIETY (at 11 Chandos Street, W.1), at 8.30.—F. Llewellyn Jones: The League of Nations and the International Control of Dangerous Drugs.
INSTITUTION OF MECHANICAL ENGINEERS (Cardiff Branch).—Prof. H. L. Callendar: Critical Relations between Water and Steam (Thomas Hawksley Lecture).

FRIDAY, NOVEMBER 29.

INSTITUTION OF MECHANICAL ENGINEERS, at 6.—R. H. Parsons and others: Debate on The Registration of Reliable Tests of Power Plant Machinery.
JUNIOR INSTITUTION OF ENGINEERS (Informal Meeting), at 7.30.—W. C. Freeman: Modern Welding Systems and Applications.
LEICESTER LITERARY AND PHILOSOPHICAL SOCIETY (Chemistry Section) (jointly with Leicester Association of Engineers) (at College of Technology, Leicester), at 7.30.—Dr. J. N. Friend: Science in Antiquity.
INSTITUTION OF AUTOMOBILE ENGINEERS (Scottish Graduates' Section) (at 51 West Regent Street, Glasgow), at 8.—J. W. Robertson: Two-stroke Engines: Some Experiments on a New Type.

SATURDAY, NOVEMBER 30.

ROYAL SOCIETY, at 4.—Anniversary Meeting.

PUBLIC LECTURES.

FRIDAY, NOVEMBER 22.

KING'S COLLEGE (at 40 Torrington Square, W.C.1), at 5.30.—Dr. O. Odlozilik: Outlines of Czechoslovak History (I.): The Geography of Czechoslovakia.
SURVEYORS' INSTITUTION, at 5.30.—Dr. A. W. Hill: Kew and its Relation to Botanical Enterprise in the Empire (Institution of Professional Civil Servants' Lecture).
ROYAL SOCIETY OF ARTS, at 8.15.—Prof. A. E. Boycott: The Causes of Cancer (Chadwick Lecture).

SATURDAY, NOVEMBER 23.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—Miss I. D. Thornley: Village Life in the Middle Ages.

MONDAY, NOVEMBER 25.

UNIVERSITY COLLEGE, at 2.—Prof. H. Spencer: Medicine in the Days of Shakespeare.
LONDON SCHOOL OF ECONOMICS, at 4.30.—E. H. Warmington: The Debt of Medieval Explorers to Ancient Discoverers: The Exploration of Inner Africa.
UNIVERSITY OF LEEDS, at 5.15.—Dr. F. W. Aston: Atomic Masses.
SCHOOL OF ORIENTAL STUDIES, at 5.30.—Dr. W. R. Rickmers: The Alai—Pamirs—a Geographical Background of Oriental Studies. (Succeeding Lectures on Nov. 26 and 28.)

TUESDAY, NOVEMBER 26.

UNIVERSITY OF LEEDS, at 8.—Prof. M. J. Stewart: Disease.
MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY (Manchester).—Dr. G. C. Simpson: Past Climates (Alexander Pedler Lecture of the British Science Guild).

WEDNESDAY, NOVEMBER 27.

ROYAL INSTITUTE OF PUBLIC HEALTH, at 4.—Prof. S. L. Cummins: Some Aspects of the Tuberculosis Problem.
SCHOOL OF ORIENTAL STUDIES, at 5.15.—A. Lloyd-James: Accent as an Element in Speech.
KING'S COLLEGE, at 5.30.—Prof. R. R. Gates: The Contribution of King's College to the Advancement of Learning during the Century 1829–1928: The Sciences of Life.
UNIVERSITY COLLEGE, at 5.30.—L. McColvin: Some Aspects of the Future of Public Library Work.
INSTITUTION OF ELECTRICAL ENGINEERS, at 5.30.—Dr. C. H. Lander: Physics in Relation to the Utilisation of Fuel (Institute of Physics Lecture).
NORTHAMPTON POLYTECHNIC INSTITUTE, at 7.—Dr. H. J. Gough: The Strength of Metals in the Light of Modern Research (Armourers and Brasiers' Company Lectures) (I.). (Succeeding Lectures on Dec. 4 and 11.)

FRIDAY, NOVEMBER 29.

COLLEGE OF MEDICINE (Newcastle-upon-Tyne), at 8.—Prof. A. E. Boycott: The Causes of Cancer (Chadwick Lecture).

SATURDAY, NOVEMBER 30.

HORNIMAN MUSEUM (Forest Hill), at 3.30.—H. N. Milligan: The Hydra in Fact and Fiction.

CONGRESS.

NOVEMBER 22 AND 23.

PUBLIC WORKS, ROADS, AND TRANSPORT CONGRESS (at Royal Agricultural Hall).
Friday, Nov. 22, at 11 A.M.—B. P. Davies: Economical and other Considerations in connexion with Roads and Bridges.—H. P. H. Morgan: Practical Points to be considered in the Improvement and Widening of Main Roads.
At 3.—W. J. Jones: The Application of Electricity to Roads from the Point of View of Street Lighting and Traffic Signalling.—J. Hunter Smith: Reflections on the Purposes and Scope of Agricultural Education.—Capt. G. A. Wright: Land Drainage.
Saturday, Nov. 23, at 11 A.M.—R. Beveridge: Costing as an Aid to Economy.