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Knowledge and Action

THE disproportion between poverty and unemployment and the abundance made possible by power production is leading men everywhere to question the basis of a political and economic system which permits the existence of such a paradox of maldistribution. It is no longer merely a question whether effective measures could be taken if those in authority possessed sufficient knowledge and understanding of the situation, but whether the present system permits them to take any effective action without the whole system being radically reformed. The non-success which has thus far attended the efforts or pleadings of politicians is not only fast breeding a general distrust of their policies but also a disposition to consider far-reaching changes in the structure of society.

A resolution brought forward a short time ago by Lord Melchett in the House of Lords summarises fairly concisely one such point of view:

"Since under modern scientific conditions productive capacity is unlimited, and since the existence of indigence and unemployment throughout a large portion of the population demonstrates the fact that the present monetary system is obsolete and a hindrance to the efficient production and distribution of goods, in the opinion of this House the Government should bring forward immediate proposals for the economic reforms necessary to enable the subjects of this realm to enjoy the benefits to which their present productive capacity entitles them."

The significance of this resolution lies not in its premises, which might be challenged on both sides, but in the very fact of such proposals being debated in our Second Chamber. That such a challenge to our monetary system, coupled with a plea for the national planning of industrial development, limitation of profits and evolution of a characteristic national economy modelled neither on Fascist nor Soviet lines could seriously have been made in such place would have seemed incredible but a couple of decades ago.

It is idle to ignore the fact that the ordinary citizen is beginning seriously to consider the question why politics have proved so unsuccessful where science has had such great success, and if politicians persist in asserting that a radical change cannot be produced in our existing structure of society, he will be liable to retort: "So much the worse for that structure." In a recent address to the Manchester Literary and Philosophical

Society, Sir Ernest Simon expressed the opinion that the only way of providing a solution to our present problems is by scientific thought and by the application of reason to politics. Research into economic and political affairs on just such scientific lines as are applied to physics is essential and yet in Great Britain such research is almost non-existent. Sir Ernest also endorsed Prof. W. McDougall's plea that research on the physical sciences should largely be diverted to research on economic and political questions.

Evidence of the truth of these observations can easily be found in current affairs. The Salter Report on road and rail transport for example was rushed to a decision in July last but no definite action has yet been taken, and interests which are adversely affected are still able to maintain a barrage of criticism to the first steps which Sir Arthur Salter and his colleagues indicated as urgently required. This, of course, is a typical example of the effect of unscientific and rigid legislation which allows unforeseen situations to create formidable vested interests before they are tackled.

Similarly, the hiatus between action and knowledge in spite of all the lip service to the doctrine of national planning is well illustrated by the position of the textile industries in Lancashire. Through the activities of the Universities of Manchester and Liverpool, the Cotton Trade Statistical Bureau, the Manchester Chamber of Commerce and the various regional planning committees, Lancashire is probably the most completely surveyed area in Great Britain. Lancashire opinion has not been mobilised, however, and the chaotic condition of the cotton industry robs it of any power to influence national policy. We are still without any organisation filling the gap between the type of financial assistance supplied by the city and that required by industry to modernise its plant and improve its marketing organisation, as the chairman of the Lancashire Industrial Development Council, Mr. T. D. Barlow, has pointed out in a letter to the Prime Minister.

On the further plea for Government control and guidance of new industrial enterprise to avoid economic waste, the developments in the canning industry accentuate the need for national policy and action. The rapid erection of new canneries while the majority of those in existence are working at only half capacity jeopardises all planned development for canning, and this new industry, which had every opportunity of starting with a clean slate and avoiding the mistakes which have handicapped the growth of other such industries, is threatened with similar loss of capital and general discouragement through low prices.

It is unnecessary to multiply examples of the imperative need of decisive Government action allied to adequate knowledge in accordance with some deliberate plea on scientific lines, though even more striking evidence could be advanced from the international sphere—disarmament, the tariff situation, Manchuria. However, it is as well to recall that the present position is not entirely novel and differs more in degree than in character from that pointed out by such an acute observer as Walter Bagehot more than half a century ago. Writing in "Physics and Politics", he notes as one mark of advancing civilisation "a diffused disposition to weigh evidence, a conviction that much may be said on every side of everything which the elder and more fanatic ages of the world wanted". To those who urged that not only did committees and parliaments fail to act with rapid decisiveness but also that no one now so acts, he replied that when we have a definite end in view, which we know we want, and which we think we know how to obtain, we can act well enough.

Bagehot's argument that the check which deliberation and discussion have placed on irrational impulse and hasty action is an untold benefit to humanity is further supported by his reminder that the impatience and excessive activity of man is one reason why science came so late into the world and is so small and scanty still in its influence. In the half-century since he wrote, however, the difficulty of relating action to knowledge has become far more acute. Not only is much more demanded of the statesman, administrator and politician, but more also is asked of the electorate. It has to be recognised that frequently public opinion, as Sir Ernest Simon pointed out, will not permit the Government to take right action. To quote a recent address by Lord Irwin: "the democratic State depends ultimately on the average judgment of its average members and it should be one of the main objects of education not to conduct mass propaganda but to win for the young the gift of right judgment in all things and the power to distinguish in public affairs and policy between the genuine coins and the spurious counterfeits".

The misgivings regarding the future of democracy which have been expressed by General Smuts, Mr. H. G. Wells and others are largely prompted by the experience of the power of democracy revealed in

the last ten years and the danger of prejudices and passions being inflamed, amid which only the demagogue and not the statesman can gain a hearing. For the selection of the right kind of representatives in this scientific age an educated electorate is essential—informed, honest, public-spirited voters capable of electing representatives qualified by knowledge as well as by eloquence, and capable of trusting their representatives to deal with the problems and situations confronting them.

The enthronement of reason in politics outlined in Sir Arthur Salter's ideas, as in Lord Melchett's or Capt. Harold Macmillan's suggestions for an industrial parliament, involve nothing less than a revolution in democracy. While, however, there is much ground for misgivings in recent history alike in Great Britain and in the United States, there are also hopeful signs to be found of the coming of a new order.

Inadequate as the distribution of leisure at the present time may be, the extent of leisure in the modern world is growing and assuming an increasing importance in the life of each individual. The opportunities for education and for forming an intelligent opinion upon public affairs are multiplying and are being increasingly used, even if there is ample room for improvement. On the other hand, there is already an increasing disposition to experiment in our social and private lives, a sufficiently pronounced tendency to be described by Dr. C. Delisle Burns as the most important social change of the past fifty years.

This readiness to experiment is already disposing many to face the break from traditional methods or outlooks, if thereby there is any reasonable hope of redressing the balance in the present distribution of leisure and work, productive capacity and consumption. There are welcome signs of a new attitude towards science and an increasing disposition both to try new methods and to insist on the relation of administrative or executive power with full knowledge of the technical or scientific issues. The increasing efficiency of the instruments of social change is a further hopeful factor. What is in doubt is whether the progressive forces can be organised sufficiently rapidly for effective action, before the continued misuse, either in industry or in politics, of the immensely greater destructive forces released by the application of scientific discoveries, involves us in irremediable social or economic disaster. The support of scientific workers is an indispensable factor in safeguarding society, and its effective mobilisation is long overdue.

De Sitter's World

Kosmos : a Course of Six Lectures on the Development of our Insight into the Structure of the Universe, delivered for the Lowell Institute in Boston in November 1931. By Prof. W. de Sitter. Pp. xii + 138 + 12 plates. (Cambridge, Mass. : Harvard University Press ; London : Oxford University Press, 1932.) 9*s.* 6*d.* net.

THIS book affords the world an opportunity of knowing Prof. de Sitter for what his many friends have long known him to be, a great lover of science and a great lover of art. De Sitter speaks to the English-speaking peoples in a tongue which is not his own by birth, but which he uses with an unstrained eloquence that brings vivid pleasure. He does so by right of his own distinguished contributions to a great subject ; and he conceals his weight of technical learning under an appealing simplicity of diction. In these lectures not only astronomers and astrophysicists but also all inquirers after knowledge are shown plainly what de Sitter thinks about the world and why he thinks it worth while to go on thinking about the world. We have here no attempt to stun the reader by force of huge distances, no attempt to drug him with doses of inconceivable periods of time. The book gives the real reasons why men working at astronomical science have drawn the picture as they present it to-day.

The lectures are in form a historical account of astronomical discovery. They deal with the Ptolemaic and Copernican systems, with the great work of Kepler, Galileo and Newton, with the first ideas of the sidereal system developed by William Herschel, with Kapteyn's masterly statistical synthesis of modern observations of what we must now call the nearer stars, with a picture of the galactic system as a whole as expressed in the work of Shapley, J. S. Plaskett, Oort and others, and lastly with the great problem of the expanding universe of spiral nebulæ.

The solar system is definite enough. But the 'local cluster' and the galactic system are, one a convenient working hypothesis for certain purposes and the other a largely unknown monster. Perhaps all will not accept every detail of the picture as painted by de Sitter. It is not certain that a galactic rotation is the only legitimate interpretation of the observed double wave in the radial velocities and proper motions ; the evidence

for the local cluster is hard to reconcile with galactic rotation; and the phenomenon of star-streaming has not been adequately fitted in to the scheme. These points are discussed by de Sitter in a stimulating way.

Most readers will reserve their greatest interest for de Sitter's handling of the problem to which he has himself notably contributed—the structure of the world of nebulæ as 'smoothed-out'.

Here we must examine both de Sitter's philosophy of science and his present attitude to the problem. De Sitter says that the ultimate aim of science is to discover as much as is discoverable about the reality behind the phenomena. Surely this is not the aim of science, whatever may be the aim of philosophy. De Sitter defends his view by urging that "the laws of nature, after all that is relative, due to the observer, has been eliminated, *are* for us the reality". Again, later, he says, "the development of science is in the direction to make it less subjective, to separate the observed facts from that which belongs to the reality behind the phenomena, the absolute, from the subjective element which is introduced by the observer, the relative. Einstein's theory is a great step in that direction. We can say that the theory of relativity is intended to remove entirely the relative and exhibit the pure absolute".

The reviewer would ask whether the aim of eliminating the observer is in the last resort a legitimate one. In atomic phenomena, the measurements of times and energies, of positions and velocities, have been shown to be related by Heisenberg's uncertainty principle, so that there the act of observation itself cannot be eliminated. In macroscopic phenomena, the observer is eliminated by the construction of 'space-time'. Einstein's special theory of relativity did not abolish the observer: it correlated the observations of two observers in uniform motion. Minkowski showed how these different observations could be welded together into a set of world-lines in space-time. But this does not justify us in assuming space-time to be the real stuff of which the world is made, for that there exists a reality independent of the observer is a pure postulate. Science is concerned with the class or aggregate of all observers' observed worlds, and not with some hypothetical temporo-spatial structure behind them. For each separate observer, the complete time-sequence of his world-views is for him the reality.

The hypothesis that 'space-time' is an element of the real nature of the physical world is deep-rooted in most treatments of the cosmological problem. De Sitter says, "We have no intuitive knowledge of the kind of space we live in. As we are concerned with *physical* space. . . ." Thus he assumes that there is a real existent, 'space', a constituent of the world, capable of being explored. What the properties of the existent space may be has recently been the subject of detailed inquiry by O. Heckmann, de Sitter and Einstein. It has been shown that solutions of the gravitational field equations for the world may be obtained for space of positive, zero or negative curvature, and that various laws of gravitation, with and without the famous λ-term, may be employed. De Sitter has shown (and he emphasises in "Kosmos") that we shall never be able to say anything about the curvature of space without introducing certain hypotheses. This seems to make it doubtful whether the phrase 'physical space' has any objective content at all. If its curvature can never be ascertained, if its curvature is essentially unobservable, then 'physical space' is essentially an arbitrary thing chosen for convenience in describing the world and capable of being chosen in different ways. We are fully entitled, for example, to choose ordinary Euclidean space. This was the point of view of Poincaré. We must, of course, recognise that different ways of choosing space will lead to different forms of expression of the same physical laws. This is illustrated by the inter-relationship shown by Heckmann and de Sitter to exist between the assumed sign of the curvature of space, the assumed sign of the λ-term and the observable quantities, namely the mean density of space and the rate of recession of the nebulæ.

De Sitter concludes that the theory of the expanding universe is at the present moment much less definite than it used to be. "We do not even know whether the curvature is positive, zero or negative, whether the universe is finite or infinite." It would appear preferable to say that questions as to the curvature have no objective content, for the answer is within the analyser's choice, but that questions as to the finiteness of mass or finiteness of volume of the universe have an objective content and are capable of answer either by extended observation or by the application of general principles. De Sitter reminds his readers that the conclusions derived about the

expanding universe depend on an assumed homogeneity and isotropy, and that it is not inconceivable that this hypothesis may have to be given up, or modified, or differently interpreted. The uncertainties in the present views on the structure of the universe seem thus to arise out of the assumption of an underlying reality, space-time, and the assumption of homogeneity. De Sitter's last judgment is that our conception of the present state of the universe bears all the marks of a transitory structure. His account of the problem may be commended as a highly objective and dispassionate scientific study, free from all mysticism, possibly the best account available.

E. A. M.

Further Light on the Schneider Mediumship

National Laboratory of Psychical Research. Bulletin 4: An Account of some Further Experiments with Rudi Schneider; a Minute-by-Minute Record of 27 Séances. By Harry Price. Pp. 199+23 plates. (London: National Laboratory of Psychical Research, 1933.) 10*s.* net.

THIS book is a vivid account of a series of sittings held in 1932 under the auspices of the National Laboratory of Psychical Research, an organisation directed by Mr. Harry Price and supported by a number of people interested in the subject, such as Dr. Hans Driesch, Prof. William McDougall, Prof. J. C. Flügel, Dr. R. J. Tillyard and Dr. Eugène Osty. The medium under investigation was Mr. Rudi Schneider, who has already been the subject of several books, of which one, concerning recent developments, was reviewed in these columns on June 25, 1932. It is as a supplement to that work that the present volume is especially interesting.

The problem of the Schneider brothers and of their mediumship has for long excited the most embittered controversy. Suspicions have been freely ventilated, but it was not until about 1925 that light began to be apparent. It was suggested that in order to describe the phenomena in normal terms the use of a confederate must be assumed. In order to test this hypothesis Mr. Warren J. Vinton, an American observer and a former colleague of Dr. E. J. Dingwall in the latter's private inquiry into the phenomena of Mr. Willi Schneider, visited the Schneider family in Austria, and in his report describes the methods used by the brothers in their séances. He states that he came into contact with what seemed to be a figure crouching behind the medium's chair; and, in a brief but brilliant analysis, shows how the phenomena could be roughly divided into two main classes—those produced with the aid of a confederate and those produced by the surreptitious freeing of one hand from the control.

In 1927 the use of the confederate was studied by an official of the American Society for Psychical Research who was previously highly unsympathetic to the theories evolved by Dr. Dingwall and Mr. Vinton, but who later admitted in his report that all the essentials of that theory were verified and all the conditions required for its fulfilment were reproduced.

In 1929 and in 1930 further experiments were conducted by Mr. Price in London. Striking phenomena were recorded and again it seemed clear that, if the manifestations were normally produced, confederacy must be assumed.

In 1931 and 1932 Mr. Rudi Schneider was in Paris under Dr. Eugène Osty, the Director of the Institut Métapsychique and a vice-president of Mr. Price's organisation. A series of remarkable phenomena was recorded. It was alleged that the medium possessed the power of externalising a 'force' or 'substance' which demonstrated its presence by interrupting infra-red rays. The report was received with considerable interest in scientific circles, although the record, as printed, lacked many details wholly necessary to a proper understanding of Dr. Osty's methods. Further light is now shed upon these by Mr. Price, who reveals the fact that Dr. Osty was aware of the presence of a confederate in his own laboratory, whilst omitting this significant fact in the official report of the sittings held at the Institut.

The present work carries the inquiries a step further. It does more than that. It gives as intimate a glimpse of the conditions obtaining at 'scientific' inquiries as Mr. Vinton's report gave of the conditions in the Schneiders' own home. The ear-deafening uproar: the forced gaiety of the observers: the attempts to distract the attention and to stifle every sense: the groaning and panting of the medium and the occasional screams of the sitters—all the features which make up these exasperating inquiries are found faithfully recorded in these graphic records.

On one occasion a photograph was taken in which the left hand of Mr. Rudi Schneider is seen,

freed from the control and stretching backwards towards the cabinet curtains. This is the first piece of photographic evidence illustrating this manœuvre, although its constant occurrence has been suspected for many years. In another photograph Mr. Willi Schneider is shown in the early stages of his 'mediumship' in the process of demonstrating an alleged materialisation attached to a curtain by a safety-pin!

As regards the supposed psychic interruption of infra-red rays as recorded by Dr. Osty, Mr. Price states that, although results were obtained with one piece of apparatus, with another much more sensitive instrument supervised by officials from the Radiovisor (Parent) Co., Ltd., no abnormal changes whatever were registered.

Such are the new facts in the history of the Schneider mediumship. The theories of confederacy and the freeing of one hand from the control have both received further support; and nothing of any importance has been added to indicate that Mr. Rudi Schneider possesses any supernormal faculties whatever.

Francis Bacon

Francis Bacon: a Biography. By Mary Sturt. Pp. xvi + 246 + 12 plates. (London: Kegan Paul and Co., Ltd., 1932.) 10*s.* 6*d.* net.

IT is many years since we were last given a life of Francis Bacon and in the interval science has come to play an essential part in the very machinery of the State as in its structure and every-day business. We have reached a stage in the world's development when its continued progress demands that the man of science assume those ruling functions which Bacon portrayed him as exercising in the "New Atlantis". While, therefore, the "Novum Organum", the "Advancement of Learning" and the exquisite fragment the "New Atlantis" have a meaning for us which the Victorian age could scarcely have sensed, the general impression of Bacon is derived largely from his own essays, coloured by Macaulay's brilliant but unbalanced polemic.

In the present volume, Miss Sturt endeavours to restore the balance and set the figure of Francis Bacon in a true perspective against the passions and prejudices, the schemings and struggles for power in the midst of which he moved for fully forty years. The story is indifferently told and the biographical material is second-hand, but we see the essential Bacon as he may have appeared to his contemporaries—cold, always old for his years, ambitious, indefatigably industrious, shrewd and competent; a man whose talents inevitably led him to the highest legal office, yet much more than the mere lawyer, for his interests extended to literature, to philosophy, to the theory of science, to gardening; and whatever he touched he adorned.

The pageantry of Elizabethan and Stuart life against which Miss Sturt sets her subject is apt to distract or confuse the mind, but the book gives a popular version of Spedding's work which, if disdained by the scholar, should be of value to the general reader.

From the point of view of the scientific worker, the space devoted to Bacon as a philosopher of science is all too meagre. A skilful exposition of Bacon's contribution to the philosophy of science should indeed be of value in the present age when every laboratory might be decorated with his texts and every international society turn to him for a motto. Of Bacon as a philosopher Miss Sturt writes with sympathy and insight, but a brief, popular exposition of his views on science as set forth in the "Advancement of Learning", in the "Novum Organum" and in the "New Atlantis", so sadly neglected by most scientific workers, is long overdue. Even the brief outline contained in the present work, however, should serve as a timely reminder of Bacon's place as one of the true prophets of modern science and induce scientific workers to consider anew his attempt to formulate a technique of discovery, and his vision of a State where the man of science is ruler and where knowledge is harnessed to man's needs.

This vision, born of Bacon's closing years of adversity—he died on April 6, 1626—has the human qualities so often disregarded in ideal commonwealths, and reveals Bacon as one who first in the modern world looked full at facts. To him there was no sphere of life to which scientific thought did not penetrate and he saw too that the scientific method did not rob life of its human values. This vision and the balance of his mind suggest indeed that it is perhaps to a combination of the legal mind trained to assess values, and the scientific mind with its capacity to explore the facts, that we must look for the quality of mind demanded of leaders in the modern State, of whom Francis Bacon himself is both forerunner and type. R. B.

Short Reviews

Before and After Socrates. By Prof. F. M. Cornford. Pp. x+113. (Cambridge: At the University Press, 1932.) 4*s.* 6*d.* net.

THE elementary character of these lectures scarcely veils the scholarly and human vision of Greek philosophy, hinted at by Prof. Cornford. Taking Socrates as the central figure of Greek philosophy, he describes how the early Ionian science failed to satisfy him, and how the systems of Plato and Aristotle attempt to carry into the interpretations of the world the consequences of Socrates' discovery. The reading of Prof. Cornford's book adds to one's conviction that the fundamental problems of knowledge, as treated by the Greeks, bear a strange resemblance to the major preoccupations of to-day's thinkers. T. G.

The Electrical Age: being Further Everyday Marvels of Science. By V. H. L. Searle. Pp. 229+3 plates. (London: Ernest Benn, Ltd., 1932.) 10*s.* 6*d.* net.

THE variety of content of this book will appeal to those who are interested in the application of electrical science to everyday life. Mathematical methods are avoided in order to help the general reader, but the author writes with care for detail as he deals with such diverse subjects as a Sprengel pump, the measurement of time, of high and low temperatures, and the manufacture of gramophone records. The volume provides, in a very readable form, scientific descriptions of many electrical devices, with non-technical statement of underlying principles.

Archaic Tracts round Cambridge. By Alfred Watkins. Pp. 61. (London: Simpkin Marshall, Ltd., 1932.) 3*s.* 6*d.*

MR. WATKINS applies his well-known theory of the sighting relation of prehistoric roads and trackways to mounds, earthworks, churches (as marking older sites), cross-roads, etc., to the Cambridge district. This is the result of a flying visit and most of the work has been done 'on the map'. The author has elaborated a further theory that roads were aligned in reference to cardinal points. The theory is also worked out here for some of his surveys in Herefordshire. Mr. Watkins's work is stimulating, though opinion may differ as to its interpretation.

Practical Physics. By William R. Bower in collaboration with Prof. J. Satterly. Third edition (revised and enlarged). Pp. viii+492. (London: University Tutorial Press, Ltd., 1932.) 7*s.* 6*d.*

THAT a third edition of this well-known book is called for is clear evidence that it meets a real need in a satisfactory manner, and no one concerned with the teaching or supervision of practical physics will need informing as to its quality. Opportunity has been taken thoroughly to revise the book and bring it into line with modern teaching and examination requirements, increasing its value by the inclusion of new experiments and descriptions of current laboratory practice and apparatus.

Das Vorwort zur Drogenkunde des Bērūnī. Eingeleitet, übersetzt und erlautert von Max Meyerhof. (Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin, Band 3, Heft 3.) Pp. 52+18. (Berlin: Julius Springer, 1932.) 7.80 gold marks.

THIS is a very welcome critical translation of the famous "Kitab-i-saidana", referred to for the first time by H. Beveridge in 1902, which exists only in the Persian translation of Abu Bakr. It gives a mass of useful information about certain drugs and chemicals used in the early Middle Ages, and contains precious indications about the corresponding Greek renderings of these substances.

Handbuch der anorganischen Chemie. Herausgegeben von Prof. Dr. R. Abegg, Dr. Fr. Auerbach und Prof. Dr. I. Koppel. In 4 Bänden. Band 4, Abteilung 3, Teil 2B, Lief. 2: *Komplexe Cyanide des Eisens.* Pp. Bxvii–Bxx+B465–B674. (Leipzig: S. Hirzel, 1932.) 24 gold marks.

A DETAILED account of the complex cyanides of iron, with a bibliography which includes 1,360 references. The frontispiece is a reproduction of early references to Prussian blue by an anonymous writer in 1710, by Woodward and by Brown in the *Philosophical Transactions* of 1724 and by Stahl in 1731.

The Philosophy of a Scientific Man. By Paul R. Heyl. Pp. 182. (New York: The Vanguard Press, 1933.) 1.50 dollars.

THIS book, which makes delightful reading, could not pretend to contain anything new. It is an act of faith of a scientific man, an act of faith in the purposiveness of the universe and in the power of our reason to apprehend the vague outlines of the reality in which we are embedded. In spite of some hasty generalisations and technical inaccuracies, it should be considered as a valuable testimony at a time when it is still fashionable in certain quarters to disclaim any value for the transcendental concepts of philosophy.

Vox Naturae. By Edwyn Terbea. Pp. 191. (London: Arthur H. Stockwell, Ltd., n.d.) 6*s.* net.

INDEPENDENT thinkers need every encouragement when they realise the difficulties of the problems of knowledge and conduct, and the relative value of their contributions to their clarification. Mr. Terbea's philosophical outlook will thus appeal to many, in so far as he treats most issues with common-sense and conviction, using as explanatory principles the interfusion of primal, sexual and intellectual urges. T. G.

Progressive Lightning: A New Stereoscope

By Dr. C. V. BOYS, F.R.S.

A MOST interesting and illuminating paper on the subject of progressive lightning by Dr. E. C. Halliday[1] describes the results of successful experiments made by himself in South Africa at the instance of Dr. B. F. J. Schonland with an instrument similar to that which I made in the year 1900. As I gave the first description of my instrument in NATURE[2] and have contributed other articles on this subject exclusively to these columns[3] I should be glad to use the same medium for some observations on Dr. Halliday's paper and at the same time describe a new stereoscope designed to examine these photographs without cutting them and also to obtain the physiological advantage of contrast due to reversed stereoscopic effect.

The method of examination of the progress of a lightning flash depends on the use of two images of the flash carried over a photographic plate at a high speed in opposite directions, or of a photographic plate or film carried past two images of the flash in opposite directions. If, then, any part of the flash is subsequent to any other part to an extent visible on the images, these will be distorted in opposite directions and a comparison of the images will give all the information available.

I had the temerity to invent this method of attack in the year 1900 and within a week I had constructed myself an instrument for the purpose. I carried this instrument about, chasing lightning without success, until in the year 1928 I caught up with a flash in America. This photograph, reproduced in NATURE of September 1, 1928, clearly demonstrated that my idea that lightning might occupy some appreciable time while blazing its trail was correct, and Dr. Halliday's photographs confirm this as well as my prediction that an immediately subsequent flash along the same path would be so quick that no aberration would be apparent in the images.

Dr. Halliday's instrument is somewhat less powerful than mine of 1900 but it appears to be ample for the purpose of getting measurable aberration. These instruments are far less powerful than that which Mr. Loomis has at Tuxedo Park, New York, or than the one of similar design which Prof. Adolf Matthias informed me in 1929 that he was going to make. I have not heard whether this instrument ever was made or, if so, whether he has obtained any results. Mr. Loomis and Prof. R. W. Wood have been hunting lightning for two summers with the instrument illustrated diagrammatically in NATURE of July 13, 1929, but so far without success. This perhaps is not surprising, since it was twenty-eight years before I caught a single flash. Thanks to the courtesy of Mr. Goodlet of the Metropolitan-Vickers Electrical Co., Ltd., I was able to test this instrument on their high tension sparks before sending it out to Mr. Loomis. There was never any question of observing progressive development of the 5-ft. spark, but the photographs were so perfect, more especially when Tesla sparks were examined, that the good behaviour of the instrument was assured beforehand. This instrument was constructed by Messrs. Ross, Ltd., at their Clapham works and it is as perfect as such a thing can be. My only fear was that perhaps lightning might be too slow for corresponding pairs of images to be recognisable as being of the same flash.

My method of investigating the progress of a lightning flash has also attracted attention in Western Australia and in Western America, but not apparently in England. I need scarcely say that it has been a source of great satisfaction to me to see Dr. Halliday's paper on his work in South Africa. He sent me an advance draft last autumn but I felt unable to make any reference to it until it had appeared. For this reason I have held back for six months the description herewith of a new stereoscope for observing the progressive character of a flash. That is, unlike any other stereoscope, the instrument indicates time or delay and not solid form.

Coming now to Dr. Halliday's photographs, my object just now is to consider not exactly how his flashes behaved, where they started or how long they took to cover their course, but in the first place to refer to a new point which he has made. It is a little curious that in my American flash, the two images happened to be one above the other and so to be moving horizontally at the time of the flash. Any aberration would result in a bending or a tilting in opposite directions of the two images of the flash, which was nearly vertical. In Dr. Halliday's photographs, on the other hand, the two images happened to be at about the same level and so were moving vertically. According to the aberration that I had contemplated, this would lead to a lengthening of one image and a shortening of the other, and in that case the stereoscope would indicate exactly the same time relief as with the lenses in the other position. Dr. Halliday, however, introduces a new idea. He imagines a flash starting at the cloud and moving downwards. Then he says that the starting point of the flash will remain luminous all the time that is occupied by the flash in travelling to its other end. I suppose he means that electric current would be pouring in at the starting point all this time and keeping it alight. In such case, with the images moving vertically, one image moving towards the cloud's image would, he says, be of its proper length, for the image of the upper end of the flash would be carried towards the cloud exactly to the same extent that the image of the lower end would be carried towards that of the upper end. On the other hand, the

other image would be shortened exactly as I have always contemplated. Unfortunately, Dr. Halliday had such wide angle lenses, *F* 2·7, that he had far too much light and his photographs are much spoilt by glare. In my original camera, I used about *F* 8 and with about one-eleventh of the light obtained clear images. I expect *F* 11 or even *F* 16 would give sufficient illumination for the main flash.

Now if my conclusion that the American flash began in the middle is correct, it is difficult to see where the reservoir was to keep up the current. Also, as a matter of fact, the images do not show any broadening at the centre or anywhere. Had current been poured in all the time that the flash was travelling, the image where it started would have been wider than where it finished. According to my view, this lightning flash had some similarity with the flames over a coal fire. Anyone looking at these would believe that the flames were continuous, but if he will look through a moving slit so as to catch a rapid succession of momentary views, he will see that the flame is broken up into a number of elements, and it is the travelling of these upwards in succession that gives the appearance of one long continuous flame. A cinematograph view would be of interest. Similarly, my photograph with images of the same width throughout but slightly different in shape indicates to me that the bright part of the flash travelled from the starting point to the terminal points and that the starting point was not luminous all the time that the flash lasted.

It may well be that no two flashes behave alike and I am not making any point of this difference of view. The real interest to me as an experimentalist is the evidence that the method is capable of ascertaining the facts whatever these facts may be, rather than in worrying over any initial differences in outlook. It seems to me to be far more important to find out what lightning really does than to trouble about ideas of what it ought to do.

It might be worth while to use four lenses equally spaced round a circle so as to obtain for every flash confirmatory evidence of its progress.

The New Stereoscope

Fig. 1 in Nature of September 1, 1928, was obtained by cutting a print in two and rotating each half through a right angle. To ensure this, a straight line had been ruled on the original negative close to and parallel to the line joining the two images, and the two half prints were turned through a right angle until these became vertical. I have found that if I cut up two prints and put two images on each side close together but reversed, that is each the same way up but so that one pair have their sharp edges adjacent while the other have their fading away edges adjacent, the stereoscopic effect of the two pairs is reversed and the contrast makes the effect the more conspicuous.

It is desirable, however, to be able to examine stereoscopically a print without cutting it, and if the contrast due to reversal can be obtained so much the better. This can be done in the following way. Make up a stereoscope by cutting a double convex lens in half and mounting these with their cut diameters away from one another. Then make two isosceles right angle prisms of glass truncated so that the right angle is absent and only the useful part near the hypotheneuse remains. The result is a rectangular prism with inclined ends and the rectangle is best a square. Fig. 1 shows how I have slit an ordinary reflecting prism into three pieces, utilising the two bottom parts. Mount these in two tubes so that they act as reversing mirrors when anything is seen through them. Mount these tubes above the two half lenses at eye distance and arrange that each tube can be turned on its own axis through a right angle, limited at each extremity by screw stops. If now the prisms in these tubes are so placed and moved that all their corresponding edges are always

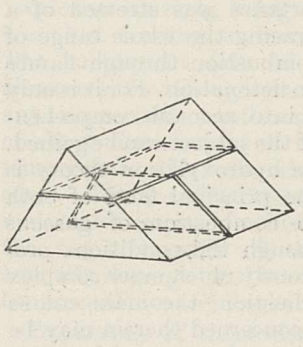

Fig. 1

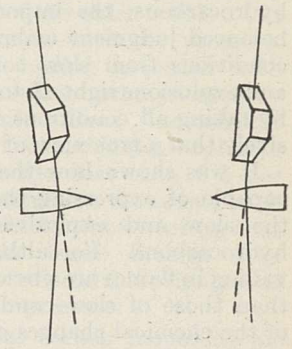

Fig. 2

parallel except for the slight convergence, and the square prisms are placed corner-wise so as to turn the images round in the same direction through a right angle as seen by the eyes, these images will then show stereoscopic relief if they are different in form due to aberration. If, then, the tubes are suddenly turned each through a right angle, the images will both be inverted in position and the stereoscopic appearance will be reversed, thus by contrast accentuating the stereoscopic effect. Fig. 2 shows the optical parts only in one position.

It may be worth while to say that the shorter the image of a flash is the greater is the stereoscopic impression, because the apparently further and nearer parts, that is, actually the earlier and later, are more closely adjacent on the plate. For this reason it is well to photograph lightning which is not nearer than four or five miles. Short focus lenses also have an advantage in this respect over lenses of longer focus. I did succeed in obtaining with my original instrument quite a spectacular photograph of lightning not a quarter of a mile away and two others on the same plate within a mile. Unfortunately, they are all so much to one side that part of one image of each is off the plate. These were obtained in the night

of August 29, 1930, when a terrific thunderstorm of blinding flashes came to St. Marybourne from Winchester, but no flashes were clear of obstruction by rain until they were close up.

Dr. Halliday has made no reference to the stereoscopic method of examination. In his photographs the process of measurement with a micrometer microscope is easy as the aberration is longitudinal. In my photograph where this is transverse, I found measurement with Mr. Loomis's fine micrometer microscope too tedious and the stereoscopic method much more convenient.

I should like in conclusion again to appeal to lightning observers suitably placed to initiate a lightning flash with a rocket. I gave some indication of what to do in my article in Nature of November 20, 1926, but if anyone should care to consider this more closely, I would recommend the construction of a 'towering rocket' of suitable proportions which should have great persuasive power. Long ago I made a 1 lb. rocket to carry a 6 oz. rocket in its head and this again to carry a 2 oz. rocket which, of course, had the usual stars. The conducting trail which such a combination creates in a very short time and up to an immense height, should initiate a flash almost with certainty if a new flash should be becoming due.

[1] *Phil. Mag.*, Feb. 1933.
[2] Nature, **118**, 749, Nov. 20, 1926.
[3] Nature, **122**, 310, Sept. 1, 1928; **124**, 54, July 13, 1929; and **127**, 425, March 14, 1931.

Researches on Gaseous Combustion*

By Prof. W. A. Bone, F.R.S.

Hydrocarbon Combustion

In reviewing, in my recent Bakerian lecture, the principal researches upon the combustion of hydrocarbons, the importance was stressed of a balanced judgment embracing the whole range of conditions from slow combustion through flames and explosions right up to detonation. For it is only by taking all conditions into account comprehensively that a true view of the subject can be gained.

It was shown how the hydroxylation theory is capable of expressing the principal facts of both the slow and explosive combustion of gaseous hydrocarbons. For although the conditions prevailing in flames are obviously much more complex than those of slow combustion, the main course of the chemical changes concerned therein may be satisfactorily interpreted on the supposition that the result of the initial encounters between hydrocarbon and oxygen is the same in both, namely, the formation of an 'oxygenated' which (except with acetylene) is a 'hydroxylated' molecule. Undoubtedly, at the higher temperatures of flames, secondary thermal decompositions occur and play a more conspicuous rôle than in slow combustion; but there are the strongest experimental grounds for believing that they do not precede the onslaught of the oxygen upon the hydrocarbon, but arise in consequence thereof. In particular, all the evidence is quite decisive against such views as that of a 'preferential' combustion, whether of hydrogen or carbon, or that in an explosion flame the hydrocarbon molecule is primarily resolved into its elements before being burnt.

Experiments were made showing that the affinities of hydrocarbons so greatly exceed those of either hydrogen or carbonic oxide for oxygen that in explosions of hydrocarbon–hydrogen (or carbonic oxide)–oxygen media deficient in oxygen the hydrocarbon is burnt, as it were, preferentially. Perhaps the most striking experiment of all consisted in exploding a mixture of 25 per cent of acetylene and 75 per cent of electrolytic gas in a stout glass bulb at a pressure of (say) 500 mm. (higher could be used but for the danger of shattering the vessel). A sharp bluish flame filled the vessel, but neither carbon separated nor did any steam condense on cooling, the products consisting of carbonic oxide and hydrogen with traces only of carbonic anhydride or of methane, in accordance with the equation:

$$C_2H_2 + O_2 + 2H_2 = 2CO + 3H_2.$$

A similar result was also obtained on exploding a mixture of equal volumes of ethylene, hydrogen and oxygen, thus:—

$$C_2H_4 + O_2 + H_2 = 2CO + 3H_2.$$

Another most arresting and significant feature of the evidence, also illustrated experimentally, was that whereas all the hydrocarbons of the C_nH_{2n} series, that is, ethylene, propylene, trimethylene and butylene, on explosion with a $C_nH_{2n} + \frac{n}{2}O_2$ proportion of oxygen always yield substantially carbonic oxide and hydrogen only, as though there had been a preferential burning of their carbon, thus:

$$C_nH_{2n} + \tfrac{n}{2}O_2 = nCO + nH_2,$$

explosions of corresponding members of the C_nH_{2n+2} or paraffin series (that is, ethane, propane or butane) with oxygen in the $C_nH_{2n+2} + \frac{n}{2}O_2$ proportion, all result in dense clouds of carbon, steam, methane and oxides of carbon. This striking difference between the behaviours of corresponding paraffins and olefines accords well with the hydroxylation theory.

Moreover, in regard to olefine explosions, another significant fact is that, so soon as the proportion of oxygen in the medium is progressively reduced below the $C_nH_{2n} + \frac{n}{2}O_2$ proportion, steam (as well as carbon) begins to appear in the products and relatively increases in amount as the oxygen content diminishes. This was demonstrated by exploding a $3C_2H_4 + 2O_2$ mixture and it points unmistakably to the initial formation of 'hydroxylated' molecules in such explosions.

In recent years, however, the suggestion has been made that the initial association of hydro-

* Substance of the Bakerian Lecture (*Proc. Roy. Soc.*, A, **137**, 243–274) and papers read afterwards at the Royal Society on Nov. 10, 1932 (*ibid.*, A, **137**, 57–83).

carbon and oxygen molecules in explosions results in a 'peroxidation' rather than a 'hydroxylation', but on closer examination the evidence of such 'peroxidation' has broken down completely. In the first place, whereas in no case of slow combustion of the gaseous hydrocarbons referred to has the postulated initial 'peroxidation' been proved by the isolation of the particular peroxide involved, abundant evidence of the initial formation of alcohols has been forthcoming from experiments on the pressure-oxidation of methane and ethane. Secondly, in the latter case, recent experiments by Dr. D. M. Newitt and Mr. A. M. Bloch in our laboratories have afforded quantitative proof of the hydroxylation theory, no peroxides whatever being found at any stage of the process. Thirdly, in such slow oxidation, the shortest 'induction' and 'reaction' periods are obtained with 2-hydrocarbon-1-oxygen instead of with equimolecular mixtures. Fourthly, experiments upon the induction period have definitely proved that the formation of an aldehyde always *precedes* that of any peroxide, the latter being rarely (if ever) observed. Finally, the 'peroxidation' theory is countered by the results of exploding under pressure methane–oxygen mixtures of compositions intermediate between $5CH_4 + 2O_2$ and $CH_4 + O_2$. Indeed, all the evidence points to any slight peroxide formation which may sometimes be observed during hydrocarbon combustion being a relatively late and minor side occurrence dependent upon a prior formation of aldehyde.

Explosions at High Pressures

In continuance of researches upon gaseous explosions at high initial pressures carried out for many years past by Drs. D. M. Newitt, D. T. A. Townend and myself at the Imperial College, we have recently published further results of experiments upon (1) hydrogen–air and carbonic oxide–air explosions at initial pressures between 250 and 1,000 atmospheres, and (2) the formation of nitric oxide in carbonic oxide–oxygen–nitrogen flames and explosions.

The previous work had resulted (*inter alia*) in the discovery of a nitrogen activation in $CO–O_2–N_2$ explosions at high initial pressures, due to an absorption by nitrogen molecules of the radiation emitted by the burning carbonic oxide, the effect steadily increasing with the density of the medium but apparently approaching a maximum at initial pressures of about 150 atmospheres, although its intensity relative to the total kinetic energy developed had been greatest at $P_1 = 75$–100 atmospheres. The new experiments were designed to show not only (*a*) how much further the effect would increase with the density of the medium, but also, (*b*) in presence of excess of oxygen, how much of the nitrogen thus activated would form nitric oxide during the explosions, the latter consideration being of importance from the point of view of a possible commercial process for the direct fixation of nitrogen.

In investigating (*a*), a special super-pressure bomb, with a cylindrical explosion chamber 3 in. long and $1\frac{1}{2}$ in. in diameter (capacity 115 c.c.), capable of withstanding explosion pressures up to 10,000 atmospheres (with a safety factor of 4), was employed; and the pressures actually developed far exceeded any yet recorded in any explosion experiments. For determining (*b*), a $2CO + 3O_2 + 2N_2$ mixture, which is the most favourable of all to the formation of nitric oxide, was exploded at various initial pressures between 40 and 88 atmospheres in a nickel-steel bomb (explosion chamber = 990 c.c.) in such-wise that at some predetermined moment during the explosion a steel disc partition was burst suddenly, liberating the gaseous products into a large 'expansion chamber' (capacity = 38 litres) from which they were afterwards withdrawn for analysis.

Theoretical hydrogen–air (that is, $2H_2 + O_2 + 3{\cdot}76N_2$) explosions went off quite normally up to an initial pressure (P_1) of 500 atmospheres, the 'explosion time', t_m, being of the order 0·015–0·022 sec., but tending to increase with the pressure. The subsequent rate of cooling accorded with Newton's law throughout, being uncomplicated by any appreciable exothermic effect; the amount of steam-dissociation at the maximum explosion temperature (T_m) was always less than 0·5 per cent. At $P_1 = 750$ atmospheres, however, such violent detonation was instantaneously set up that the screw threads of the bomb fittings were seriously damaged and it was deemed too dangerous to proceed to any higher pressure.

Explosions of theoretical carbon monoxide–air (that is, $2CO + O_2 + 3{\cdot}76N_2$) mixtures were successfully carried out at various initial pressures up to and including 1,000 atmospheres, with results showing that the nitrogen activation had reached a maximum at $P_1 = 350$ atmospheres, when its exothermic effect on the cooling curve was equivalent to some 12·5 per cent of the total kinetic energy developed. In explosions at $P_1 = 1{,}000$ atmospheres, $t_m = 0{\cdot}24$ sec., and the maximum gauge pressure (P_m) developed was 7,100 atmospheres (about 46 tons per sq. in.), with T_m just under 3000° K. The percentage dissociation of carbon dioxide at T_m ranged from 2·4 at $P_1 = 250$ up to 5·5 with $P_1 = 1{,}000$ atmospheres.

The $2CO + 3O_2 + 2N_2$ explosions (*b*) showed not only the beneficial influence of pressure upon the nitric oxide formation, but also that in all cases it begins during the 'combustion period' and extends far into the 'cooling period'. Thus, whereas at $P_1 = 70$ atmospheres only about 3·3 per cent of nitric oxide had been formed up to the moment of maximum pressure ($T_m = 2900°$ K.) as much as 5·4 per cent was present some 0·06 sec. thereafter; and at $P_1 = 88$ atmospheres the maximum nitric oxide formation would be of the order of 6 per cent. Such yields of nitric oxide are many times higher than any previously obtained in explosions.

Obituary

Prof. G. C. Bourne, F.R.S.

THE death on March 8 of Gilbert Charles Bourne, emeritus professor of zoology and comparative anatomy in the University of Oxford, will be deplored by his colleagues and many friends in Oxford and elsewhere. The sudden ending of such a remarkably active and useful life will be felt as a serious loss.

Since 1919 and up to his last illness, Prof. Bourne had, with characteristic energy, taken a prominent part on the Advisory Committee on Fishery Research to the Development Commission of which he eventually became chairman, succeeding Sir William Hardy in 1931. The success of the Freshwater Sub-Committee, of which he was also chairman, owed much to his untiring labours, his wide knowledge of biology and his business ability. No less valuable were his services to the Water Pollution Research Board of the Department of Scientific and Industrial Research. Under his chairmanship of committees a thorough biological, chemical, and hydrographical survey of the River Tees was carried out and similar work undertaken on the Mersey.

Of a friendly, sanguine, and generous disposition, and actuated by a strong sense of public duty, Bourne was always ready to serve his country in peace or war. As a young man, he joined the Volunteers and the militia in which he rose to the rank of Lieutenant-Colonel (Hon. Colonel). During the War he was chiefly engaged in the training of recruits.

Bourne's fame as an oarsman nd a rowing coach is known to all. His versatility was indeed remarkable. There were few practical things he could not do and do well. He seemed equally proficient with the oar or the marine trawl, the microscope or the sporting gun.

Born in 1861, the son of Lieut.-Col. Robert Bourne, of Cowarne Court, Herefordshire, he was educated at Eton and New College, Oxford. Always interested in natural history, he studied zoology under Prof. H. N. Moseley, worked for a short time with Prof. Weismann in Freiburg, and, after taking his degree, started on his scientific career. A description of the anatomy of the millipede, *Sphærotherium*, more especially of its stridulating organ, read before the Linnean Society in 1885, was his first publication.

In the same year Bourne visited Diego Garcia, that lonely tropical island set in the midst of the Indian Ocean. Here he studied corals, having joined that band of enthusiasts, including A. C. Haddon, S. J. Hickson, and G. H. Fowler, who did so much to advance knowledge of these and other cœlenterates. Diego Garcia is a typical coral atoll, and Bourne was among the first to treat atoll-formation not so much as a problem of geology as one to be attacked from the point of view of biology. His observations made on the spot of the conditions under which corals live and grow, flourish and decay, enabled him to contribute an important paper to the *Proceedings of the Royal Society* in 1888. Meanwhile, on his return, he had begun a series of papers on the structure and growth of various corals, of which those on *Fungia* (*Quart. J. Micro. Sci.*, 1887) and on *Heliopora* (*Phil. Trans.*, 1896) are perhaps the most outstanding. He was also interested in the Crustacea, wrote on *Monstrilla* and other copepods ; and later made an elaborate study of crabs of the family Raninidæ, for which he founded the new tribe Gymnopleura (*J. Linn. Soc.*, 1922).

The translation of Pelseneer's masterly volume on the Mollusca for the "Treatise on Zoology", undertaken at Sir Ray Lankester's suggestion, turned Bourne's attention to new fields, and led to the appearance of several works on little-known molluscs, particularly on the Neritacea and other gastropods (*Proc. Zool. Soc.*, 1909, 1911). These various contributions on the structure and classification of the Invertebrata are all distinguished for care and thoroughness, and for the excellence of the illustrations ; for he was a patient and skilful dissector and a very accurate draughtsman. Together they form a solid and lasting addition to zoological science.

Bourne's more general works include "An Introduction to the Study of the Comparative Anatomy of Animals", one of the best elementary text-books of the kind when it first appeared in 1900, and still a useful and trustworthy guide for the student. To Lankester's well-known "Treatise on Zoology" he contributed comprehensive parts on the Ctenophora and on the Anthozoa, including, of course, his beloved corals.

Soon after taking his degree, Bourne was elected fellow of New College, and later became tutor as well. For a couple of years he went to Plymouth as director of the recently established Marine Biological Laboratory. On his return to Oxford he taught for many years in the Department of Zoology and Comparative Anatomy. In 1906 he succeeded Prof. Weldon in the Linacre chair, which he occupied with distinction until his resignation in 1921. He was elected to the fellowship of the Royal Society in 1910, and was president of Section D (Zoology) of the British Association at Sheffield in the same year.

Bourne married the daughter of Sir John Croft, Bt., who survives him with one son and one daughter. The former, Capt. R. Bourne, is now member of Parliament for Oxford. E. S. G.

We regret to announce the following deaths :

Sir John Jackson, O.B.E., deputy chief inspector of factories from 1920 until 1930, on March 19, aged sixty-eight years.

Dr. Thomas C. Porter, for many years science master at Eton College and one of the founders of the (Public Schools) Science Masters' Association, on March 31, aged seventy-three years.

News and Views

Nature of the Nerve Impulse

THE intimate nature of the nervous impulse has long been a subject for speculation by physiologists and psychologists. Simple models to explain the mode of transmission of an impulse along a nerve, like the electrical one of the marine telegraphic cable or like the chemical one of a train of gun-powder, have proved to be totally inadequate to explain the various phenomena observed in nerve. Until recently, the relative unfatiguability of nerve favoured a simple physical and non-chemical hypothesis. Modern refinements in technique, however, have shown that nerve during activity utilises chemical energy and produces heat. It is only in the last few years that the two phases of heat production in nerve have been analysed, and an account from the leading investigator in this field, Prof. A. V. Hill, appears in the special supplement to this week's issue of NATURE. Prof. Hill favours an electrochemical theory of a self-propagating wave of disturbance to explain the various forms of behaviour exhibited by an impulse in its passage along a nerve. Interesting experiments on the ionic distribution of potassium ions lend convincing support to the theory. The supplement will also be found to give a useful summing-up of the present position reached by investigators in this branch of nerve physiology.

Sir Charles Peers, C.B.E.

SIR CHARLES PEERS, Chief Inspector of Ancient Monuments and president of the Society of Antiquaries, has been awarded the Royal gold medal of the Royal Institute of British Architects for his services to architecture. The presentation took place at the Institute on April 3. Sir Charles Peers has now held office as Chief Inspector of Ancient Monuments for twenty years. It is largely owing to his zeal in carrying out his duties and the breadth of his practical knowledge in archæological matters that, not only have a large number of our antiquities been preserved from vandalism, but also the co-operation of the Office of Works, of which he is an officer, has been sought readily and with confidence by those who are interested either as owners, as archæologists, or as members of the public in the future as well as the past of ancient monuments. At the same time, the powers and duties of his office and his department, which were anything but adequate at the time of his appointment, have been enlarged by successive Acts of Parliament, until, with notable reservations to which attention has been directed with emphasis recently, such monuments are now within a measurable distance of a reasonable assurance of safety.

Trevithick Centenary Exhibition

IN connexion with the celebration of the centenary of the death of the great Cornish engineer and inventor Richard Trevithick, the 'father' of the steam locomotive, a memorial exhibition has been arranged in the main gallery of the Science Museum, South Kensington. Trevithick was an inventor of astonishing fertility but his main contribution to engineering progress was his invention of the high-pressure non-condensing steam engine and its application to both road and rail locomotives. His outstanding patent was taken out in 1802, and engines were made all over England to his designs. Of these engines two excellent specimens are shown, one with a cast iron boiler, made in 1805, and another made in 1811 with a wrought iron boiler. Unfortunately, nothing remains of his several locomotives, but various documents and drawings are exhibited and there are also some of the cast iron rails from Penydarran, South Wales, on which his first locomotive ran. This engine, the first rail locomotive in the world, is known to have drawn five wagons with a load of ten tons in 1804, and four years later Trevithick exhibited a locomotive, afterwards named *Catch-me-who-can*, "in the fields adjoining the Bedford Nursery near Tottenham Court Road", London. The next locomotive of importance was that constructed by Matthew Murray for John Blenkinsop at Leeds in 1811, but the original drawings for this were supplied by Trevithick, who received a royalty on the engine. The exhibition also includes Linnell's portrait of Trevithick painted in 1816, Burnard's bust and many interesting letters and documents.

Memorial to Thomas Tompion

ON Saturday, April 1, a plaque in memory of Thomas Tompion, the clockmaker, was unveiled in St. Mary's Church, Northill, Bedfordshire, where he was born in 1639, and simultaneously a wreath was laid on his tomb in Westminster Abbey, where he was buried in 1713. The plaque is the gift of the Clockmakers' Company and was unveiled by the Master, Mr. B. Kettle, the address at the service being delivered by the Archdeacon of St. Albans, the Ven. A. H. Parnell. At the ceremony at the Abbey, Sir Francis Newbolt, the Deputy Master of the Clockmakers' Company, said Tompion was honoured by the Company as one of its greatest Masters. So great was his mechanical genius and incessant industry that he was appointed clockmaker to the Royal Observatory at Greenwich at its foundation. He was a brilliant craftsman and made practical the theoretical inventions of others. He left English watches and clocks the finest in the world and the admiration of his brother artists. The grave Tompion lies in, it may be remarked, also contains the remains of his famous pupil and successor, George Graham, who died in 1751. The slab now to be seen in the Abbey, on which Graham's remarkable skill is referred to, was removed in 1838 and a small lozenge-shaped stone substituted. Thanks, however, to Dean Stanley, the original was replaced in 1866.

Centenary of Maurice Loewy

ON April 15 occurs the centenary of the birth of the distinguished astronomer, Maurice Loewy, who, from 1896 until 1907, held the directorship of the

Paris Observatory, a post to which he was appointed on the death of Felix Tisserand. Born in Vienna in 1833 of Jewish parents, Loewy passed through the Polytechnic School and University of Vienna and then entered the old Imperial Observatory of the capital, where he was trained by Karl Littrow. Being invited to France by Le Verrier, he became a naturalised Frenchman and in 1864 joined the staff of the Paris Observatory, serving under Le Verrier, Delaunay, Mouchez and Tisserand. He took an active part in the completion of the great Paris Catalogue of Stars and in the inauguration of the International Star Chart. So early as 1871 he proposed to Delaunay the new form of telescope since known as the equatorial *coudé*, but it was not until 1882 that the first instrument of this kind was erected, the cost of the telescope then being defrayed by the generous banker Raphael Bischoffsheim (1823–1906), the founder of the Nice Observatory. A description of the instrument appeared in Nature of November 8, 1883, p. 36. For thirty years Loewy was director of the *Connaissance des Temps*, and from 1872 was a member of the Bureau des Longitudes, taking part with Mouchez in the inauguration of the observatory in the Parc de Montsouris for the instruction of navigators and explorers. From 1873 onwards he was also a member of the Academy of Sciences. He received many honours from learned societies and in 1889 was awarded the gold medal of the Royal Astronomical Society. He died suddenly on October 15, 1907, at the age of seventy-four years, when addressing a meeting of the Conseil des Observatoires astronomiques.

Priestley Bicentenary Celebrations at Warrington

When non-conformists were debarred from studying at Oxford and Cambridge, a number of dissenting colleges came into existence, among the most famous and successful of which was the Warrington Academy, through which, during its existence from 1757 until 1783, some four hundred pupils passed. It was in this Academy that Priestley taught from 1762 until 1767, and it was there he wrote his "History of Electricity". In 1898 the Warrington Society was formed with the object of preserving the building which originally housed the Academy, and to-day it possesses an interesting collection of Priestley pictures, books and medallions. In conjunction with the Warrington Philomathic Society, therefore, it held a Priestley commemoration meeting in The Old Academy on March 17, when the Priestley relics were shown to visitors and two addresses were given, the first being by Mr. J. Hawthorn on "Joseph Priestley and Warrington" and the second by J. S. Broome on "Priestley's Scientific Work in Warrington". When Priestley was offered a post at the Academy, he followed Dr. Taylor as tutor in languages although, as he himself wrote, "I should have preferred the office of teaching the mathematics and natural philosophy, for which, I had at that time a great predilection". In spite, however, of being employed five hours a day in lecturing on English, Latin, Hebrew and other subjects, he yet found time to make experiments and carry on a correspondence with Franklin, and it was his scientific work at Warrington which led to his being admitted to the fellowship of the Royal Society.

Stereochemistry and Physics

The Faraday lecture of the Chemical Society was delivered at the Royal Institution on March 29 by Prof. Peter Debye, of the University of Leipzig. He took as his subject "The Relations between Stereochemistry and Physics" and gave a brilliant exposition of certain methods used for the elucidation of molecular shape and dimensions, methods to which his own contributions, both in theory and in experimental technique, have been all-important. Until comparatively recently, the two factors which essentially determine the dielectric constant of a substance were not clearly distinguished from one another. Prof. Debye showed how the total polarisation in an electric field is compounded of the natural polarisation inherent in the molecules themselves and of an induced polarisation, due to their electrical deformability; how the relative contributions of these two effects can be estimated by investigating the influence of temperature on dielectric constant; and how the magnitude of the natural dipole moment thus obtained can give valuable information on the degree and the nature of symmetry of the molecule. Examples were quoted from the work of Errera, Smyth and Williams.

In the latter half of the lecture, Prof. Debye dealt with his pioneer investigations on X-ray interference patterns produced by isolated molecules, describing the technique, the application of the numerous necessary corrections to the experimental data, and the interpretation of the latter in terms of the interatomic distances in the molecule. Mention was made of the related electron ray method of Mark and Wierl. He illustrated his fascinating topic by reference to work on the chlorine substitution products of methane, and to the problem of free rotation of single bonds. The interest and enjoyment of his hearers were obvious. One may indeed be excused for thinking that very seldom are occasion and lecturer, theme and audience so completely attuned to one another as happened at this lecture. Prof. Debye had no difficulty in establishing Faraday as a pioneer of ideas in the fields both of the electrical properties of molecules and of the spatial arrangement of atoms within them. All felt that Sir William Bragg was right when he claimed that Prof. Debye and Faraday were akin in spirit; Prof. Donnan was equally right when he termed Prof. Debye the friend of the chemist, of the "hydrophobic organic chemist equally with the hydrophilic physical chemist".

The Chemical Society

Prof. G. G. Henderson, the retiring president of the Chemical Society, devoted his presidential address on March 30 to an examination of the present position and the future of the Society. Scientific societies, he said, must be ready to modify their policies in accordance with changing conditions. The work of the Chemical Society in pursuing the

objects for which it was founded has increased during the past year, and the work of the Bureau of Chemical Abstracts also reflects the ever-increasing amount of investigation which is being performed in the chemical field. New decisions which will help to meet modern needs include devoting a larger number of meetings to organised discussions and summaries of recent work, offering fellowship to young chemists at half the annual subscription, selecting the papers to be read at ordinary scientific meetings, arranging that some of the endowed and special lectures shall be delivered elsewhere than in London, and appointing local representatives who will arrange lectures or discussions in collaboration with the local secretaries of other chemical organisations, and will generally promote the interests of the Society. The Council does not contemplate the establishment of local sections of the Society, since numerous local sections of the Institute of Chemistry, the Society of Chemical Industry, and of other societies are already in existence.

Federation of Chemical Societies

PROF. HENDERSON also referred to the new format of the *Journal* of the Society, and remarked : "I trust that the combined effort of the Chemical Society and the Faraday Society to produce a joint publication, which is destined to be the representative journal of British physical chemistry, will be brought to a successful issue, and that the new journal will appear next year". New conditions have created new wants, and he feels that new methods with respect to administration, to the representation of fellows in the Council, to the production and distribution of publications, and to the association of the Society with other chemical organisations must be adopted. Federation or union of at least all the principal organisations concerned with chemistry, said Prof. Henderson, is a project which is making an appeal to an increasing number of members of the profession. Prof. Henderson referred to an article on the subject in NATURE of September 24, 1932, and quoted the conclusions, saying that they well summarise the facts which compel attention to this matter. "So long as the Society remains, as now, an independent organisation," he said, "I cannot see how a larger income is to be obtained . . . and every method of reducing expenditure which can be adopted under existing conditions has been closely investigated. The same statement applies generally to the Society of Chemical Industry, the Biochemical Society, the Faraday Society, and other societies more directly interested in various branches of applied chemistry, which publish journals or abstracts or both. Consequently one is forced to the conclusion that some form of federation of these societies is not only desirable, but sooner or later inevitable. Moreover in my opinion such a federation would be incomplete and lacking in influence unless the professional organisations were also included as members."

THE kind of federation which Prof. Henderson envisages would not involve material loss of individuality on the part of the members of the separate societies, for each has its special sphere of activity on behalf of the subject as a whole and of the profession generally. The final decision must rest with the members of the organisations concerned, but Prof. Henderson said he is confident that if chemists of all kinds got together in some such way as he had indicated, the effect would be altogether beneficial to the profession. He believes that the movement, if generally supported, would be welcomed by the chemical industry of the country. Sympathetic consideration must be given to the scheme to be put forward by the Federal Council for Chemistry, which has appointed a committee to frame proposals calculated to afford the chemical societies of Great Britain means of securing economies, increased efficiency, and mutual advantage.

Houston Expedition over Everest

THE Houston Air Expedition to Mount Everest succeeded in its object to fly over the actual peak on the morning of April 3. The flight, starting from Lalbalu aerodrome, occupied three hours, flew about 160 miles including two circuits of the peak, reached more than 31,000 ft. altitude, and actually cleared the top by only 100 ft. The two machines, a Houston-Westland and a Westland-Wallace (Bristol Pegasus S.III engines), flew in company and carried out a concerted programme of duties. The decision to make the flight was taken on the advice of the Indian Government Meteorological Station at Purnea, which reported winds of 57 m.p.h. velocity, without undue bumpiness, at 33,000 ft. altitude, by means of the usual balloon observations. Air-Commodore Fellowes, the leader, made a preliminary reconnaissance in his Puss Moth machine before making the final decision to start.

CONSIDERABLE credit is due to the crews of the Houston Expedition for their navigation, as it was impossible to adhere to the prepared scheme of observations from landmarks owing to a heavy dust haze extending up to 19,000 ft. They also met with severe down currents due to the deflection of the west wind over the mountain, causing a loss of altitude of more than 1,500 ft. in a few seconds in one case. Very good still photographs were obtained, but the results of the cinema cameras are not yet known. The automatic survey cameras were not working during part of the flight, which may mean that necessary connecting parts of the mosaic survey may be missing. In this event a further flight will be made if permission can be obtained from Nepal. The unusual clearness of the air made it difficult for the photographers to judge distances accurately. The crews were afterwards examined by the expedition's doctor, who found that they were tired, but not unduly exhausted. On April 4, a further flight was made by both machines over Kanchenjunga.

Loss of the *Akron*

WE much regret to record the total loss of the United States naval airship *Akron*, which occurred on April 4. It appears that the vessel left Lakehurst for a cruise over the coast of New England on April 3

in order to test her wireless compasses. A wireless message during the evening reported that all was well and nothing further was heard until a German tanker, the *Phœbus*, reported by wireless that the *Akron* had 'crashed' at sea and that four of the crew had been picked up, one of whom died later. One of the survivors is Lieut.-Comdr. H. Wiley, the second-in-command, who has recovered sufficiently to make a report on the disaster. The airship sighted a thunderstorm at 8.45 p.m.; later, the ship at 1,600 ft. appeared to be surrounded by lightning and about midnight she began to descend rapidly. Ballast was thrown out and she regained altitude, only to descend again a few minutes later. The rudder control was carried away as the airship crashed and it seems that the main part of the ship sunk almost immediately. The *Akron* was the largest airship in the world, her gasbags were filled with helium, and, at the time of the disaster, there were seventy-seven officers and men aboard, including Rear-Admiral William Moffett, chief of the U.S. Naval Bureau of Aeronautics. Rescue work was hampered by the weather, and a 'blimp' returning from a search for survivors was blown into the sea on attempting to land, one of the crew being drowned and the commander dying shortly afterwards. Yet another airship accident has been reported, this time from France, where the semi-rigid naval dirigible E9, crashed near Guerande on April 4, two of the crew of twelve being injured.

Science at the Ideal Home Exhibition

The *Daily Mail* Ideal Home exhibition at Olympia, which was opened by Mrs. Stanley Baldwin on March 29 and will remain open until April 29, is, as usual, a remarkable tribute to the influence science now exerts on the equipment of up-to-date houses. Thanks to the use of gas and electricity, the investigations of the chemist, physicist and metallurgist, the duties of every housewife are steadily being lightened and the comfort and convenience of everyone increased. The gradual improvement in the quality of food and in its preparation, and in all connected with lighting, heating and ventilation is indeed remarkable. New metals, new materials and new designs, and the application of scientific methods are seen on every hand. The exhibition occupies the Grand Hall, the National Hall and the Empire Hall, and in the first of these is an admirable and beautiful scheme of decoration which includes, as its outstanding feature, a portion of an immense rainbow composed of no less than 700 ft. of neon tubes, fitted up by Messrs. Venreco, Ltd.

Without attempting to refer to the many exhibits which owe so much to scientific research, attention may be directed to the interesting series of "Rooms of the Scientists" in the gallery of the Empire Hall, where "for the first time in history, are gathered together a collection of exhibits more romantic than any story, more sensational in their results than the wildest fiction". There are nine of these rooms showing respectively Archimedes in his villa at Syracuse; Roger Bacon in prison; Newton in his study at Cambridge making his experiment on light; a part of the surgical ward at the Glasgow Royal Infirmary where Lister did his important work during 1861–69; the tent of Sir Ronald Ross in which he made his observations on the relation of the mosquito to malaria; Darwin's study at Down House in which he wrote "The Origin of Species"; a replica of Prof. Piccard's sphere in which he made his record ascent into the air; Faraday's laboratory at the Royal Institution; and lastly, the wireless cabin of the Marchese Marconi on his yacht *Elettra*. The tableaux are admirably arranged and the eminent men of science are represented by members of the theatrical profession, that of Newton, for example, being played by Mr. Rodney Barrie. The whole exhibit has been staged by Prof. A. M. Low for *Armchair Science*, with the assistance of many scientific bodies and individuals, including the British Museum, the Science Museum and the Royal Institution.

Bequests for Geological Research

Mr. Bernard Hobson, of Sheffield, who died on December 3, left estate of the net value of £142,125. He bequeathed £1,000 to the Yorkshire Geological Society, Leeds; £1,000 to the Geological Society of London, to be called the "Bernard Hobson Fund", the annual income of which is to be used in buying British, Colonial and foreign geological maps, to be placed on linen conveniently folded for the pocket for use of the members of the Society; and £1,000 to the British Association for the Advancement of Science, to be called the "Bernard Hobson Fund", the annual income of which is to be devoted to promoting definite geological research. After making further bequests totalling about £3,000, Mr. Hobson left the residue of his estate to his brother and sister for life, with remainder to the University of Sheffield. Mr. Hobson had been a member of the Council of the University for some years. He belonged to a family which had taken a special interest in it. His father, Mr. John Hobson, was a member of the Council of Firth College, from which the University sprang. His brother, the late Sir Albert Hobson, as Master Cutler in 1903, took a leading part in the movement for the establishment of the University, and served successively as Treasurer of the University and Pro-Chancellor. Sir Albert, who died in 1923, also left the residue of his estate to the University.

Research Grant for the Cancer Hospital (Free), London

Recently the investigations on the chemical aspects of the cancer problem which are in progress at the Research Institute of The Cancer Hospital (Free), Fulham Road, London, have received recognition and financial assistance from two sources. The trustees of the Halley Stewart Trust have made a grant for a period of three years to support a whole-time worker who will undertake biochemical investigations into the metabolism of cancerous growths. Dr. C. A. Mawson of the Victoria University of Manchester has been appointed to carry out this work.

(*Continued on p. 509*)

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The Physical Nature of the Nerve Impulse*

By Prof. A. V. Hill, O.B.E., F.R.S.

ALL our sensations, all our movements, most of the activities of our nervous system, depend upon a certain transmitted disturbance which we call the nervous impulse: this, in the study of nerve activity, is what the atom, the electron and the quantum are to chemistry and physics. A rapid reaction to events occurring at a distance is necessary for efficient working. Special nerve cells, therefore, have been developed in all the larger animals: from these the axon or nerve fibre runs out, which is only 3 μ to 25 μ in diameter but may be many metres in length. Along these fibres wave-like messages are sent.

The velocity of a nerve impulse varies greatly according to the fibre in which it runs and to the conditions affecting the fibre. In the medullated nerve of a mammal the velocity is of the order of 100 metres per second. (Compare this with 330 metres per second, the velocity of sound.) In the medullated nerve of the frog at 20° C. it is about 30 metres per second. In the non-medullated nerve of a mammal it is said to be about one metre per second; in the non-medullated nerve of the pike and of *Anodon* respectively it is stated to be 0·2 metre and 0·05 metre per second. The velocities in this list are in the ratio of 2,000 to 1.

The nerve impulse is an event, a wave, a propagated disturbance, not a substance or a form of energy. It is transmitted along a thread of protoplasm which, in medullated nerve, is surrounded by a protecting or 'insulating' sheath. Its passage can be detected in several ways: (*a*) by its physiological effect on the organ to which it runs, (*b*) by the electric change which accompanies its transmission, (*c*) by a production of heat, and (*d*) by a consumption of oxygen and a liberation of carbon dioxide.

No difference of electrical potential can be detected in an uninjured resting nerve. If, however, the nerve be injured, for example, by cutting, a potential difference is found of the order of a few hundredths of a volt between the injured and the uninjured parts, in the sense that positive current runs in an external circuit towards the former. The injury does not *produce* the potential difference; it merely allows its normal presence across the fibre boundary to be manifested.

* Friday evening discourse delivered at the Royal Institution on Feb. 10.

If two electrodes be placed on a nerve and the nerve be stimulated, a momentary change of potential travels along it which can be recorded with an oscillograph. At any given instant a certain length of the nerve of the order of a few centimetres is found to be the site of a wave of negative potential. We are probably right in thinking that the impulse itself, whatever that be, occupies the same region and moves at the same speed as its electrical accompaniment.

Properties of the Nerve Impulse

Let us consider the properties of the impulse which is transmitted, or transmits itself, in nerve. The single impulse in the single fibre is the basis of nerve activity. Until recently, this individual impulse could not be separately examined and deductions had to be made from the results of stimulating many fibres in parallel. Of late, however, through improvements in electrical recording, it has become possible to register the form and movement of the electric change resulting from a single impulse in a single fibre.

(*A*) A single impulse has an 'all-or-none' character. Its size cannot be varied by changing the strength of the stimulus which produces it: it makes no difference to the magnitude of the discharge how hard the trigger is pulled. (*B*) An absolute 'refractory' period follows the passage of an impulse, a period during which no stimulus, however strong, can evoke a second response. In frog's nerve at 20° C. this absolute refractory period is about 0·001 sec. (*C*) As a consequence of (*B*), two nerve impulses going in opposite directions in the same fibre come each into the refractory region of the other and both are abolished. 'One way traffic' alone is possible: separate sensory and motor systems are required. (*D*) After the absolutely refractory stage a relatively refractory stage persists, during which a stronger stimulus than usual is required to start an impulse, and the second impulse, measured by electric change or heat, is smaller than the first one. Discharge can take place before recharge is complete. (*E*) As a result of the refractory phase, the frequency of transmission is limited. Prof. H. S. Gasser of New York recently informed me that he had made mammalian nerve carry 1,500

impulses per second, and that at 1,000 per sec., impulses were not greatly subnormal. In the normal functioning of the nervous system nearly all messages consist of trains of impulses of varying frequency. (*F*) The impulse at any instant occupies a few centimetres of the fibre. This length is not much altered by a change of temperature and it is approximately proportional to the diameter of the fibre. There must be some simple physical reason for these facts, as also for the next one. (*G*) The velocity of the impulse is also approximately proportional to the diameter of the fibre. Consequently in a given nerve trunk which consists of fibres of various diameters, a wave started electrically at one end gradually spreads out and appears as a series of waves corresponding to the several maxima in a frequency curve. (*H*) When the temperature is raised or lowered by 10° C. the velocity of transmission is increased or diminished in the ratio of 1·7 to 1. (*I*) The passage of an impulse is associated with a liberation of heat to which some special attention is necessary.

Heat Production of Nerve

No work is performed, no force is developed, no movement at all occurs in a nerve when it is active, and for long it was believed that in the transmission of nerve impulses no heat is evolved. Many attempts were made to measure the heat, all unsuccessful until 1925. To-day, when the heat production of nerve can be measured almost as well as that of muscle could in 1920, it is hard to believe that for many years we argued as though there was no heat at all associated with nerve activity. It is true that the amount is small, that the *total* heat (which takes thirty to fifty minutes to appear) in a single impulse in a gram of nerve is only about one millionth of a calorie, and it is true still that we must have several impulses before we can measure the heat properly, but with that provision and with present-day arrangements, the measurement is comparatively simple and accurate. The sensitivity is such (i) that a galvanometer deflection of 1 mm. (readable to 0·1 mm.) corresponds to a rise of temperature of about three millionths of a degree, and (ii) that during a steady state of heat production one millimetre of steady deflection corresponds to a rate of heat production of about 2×10^{-8} calorie per second.

The heat is produced not only during the passage of the impulse *but for a long time afterwards*; some kind of breakdown occurs, presumably as the wave goes by. This breakdown has then to be reversed, the nerve allowed to recover, in a re-charging process of some kind which takes place afterwards. The fact that heat is produced, and the manner of its production, dispose of the possibility that the nerve impulse is, to use Bayliss's words, a "reversible physico-chemical process".

At 20° C. the initial heat in a single isolated impulse in a frog's medullated nerve lies between 10^{-7} calorie and 3×10^{-8} calorie per gram of nerve. The recovery heat, which continues for a long time after the impulse has passed, is about ten to thirty times as much. During continual stimulation, say of fifty shocks per second, a steady state is gradually reached in which recovery balances breakdown, the recovery heat in any given interval representing the process of restoration from all the impulses which passed in the preceding forty minutes. During the steady state, which is possible only in oxygen, the total heat production may occur at the rate of about 25 microcalories per gram per second. At a higher frequency the total heat rate may, for a time, be rather greater, but a genuine steady state is not possible; fatigue progressively sets in. It is striking that the *resting* rate of heat production of the same nerve is about 70×10^{-6} calorie per gram of nerve per second, so that moderate activity only increases the metabolism of a nerve by a comparatively small amount, even extreme activity does not double it. The mere maintenance of the machine in working order requires more energy than the excess required when it goes full speed during activity.

This initial heat is the result presumably of some chemical reaction involved in, or immediately after, the transmission of the impulse. If we suppose the reaction to occur throughout the substance of the axis cylinder, its heat is so small that it is difficult to picture any mechanism by which the change could be propagated. There are other grounds—for example, the relation between speed and diameter—for supposing that the reaction, whatever it be, is somehow connected with the surface of the fibres. It can be calculated that the area of the surface in a gram of nerve is of the order of 2,000 sq. cm., and that the energy in the transmission of a single effective impulse is from 5×10^{-3} to $2{\cdot}5 \times 10^{-4}$ erg per sq. cm. of fibre surface. This is still a very small quantity, the smallness of which can be realised by the statement that it is 1/4,000 to 1/80,000 of the surface energy of a water–olive oil interface.

One naturally asks, may not the initial heat be really due to the electrical disturbance transmitted in nerve? If we take the observed potential differences along the nerve and assume that these cause currents to flow through the conducting media inside and outside the sheath, then the Joule's heat of the currents can be calculated. The result is only a small fraction, less than one per cent, of the observed initial heat. There is another possibility, however, namely, that the nerve is to be regarded as a charged electrical condenser which is discharged as the wave passes by. The energy of a condenser of capacity F microfarads, charged to V volts, is $5FV^2$ ergs. Taking V as 0·05 we should require a capacity of the order of half a microfarad per square centimetre of nerve fibre surface to give us the observed initial heat. There is some evidence that capacities of this size may possibly exist at the surface of living cells. If so, we should not need to look for a chemical reaction to explain the initial heat—

the electrical discharge would be sufficient. Other evidence, however, makes it unlikely that this is really the source of the heat.

The recovery process by which the nerve is restored to its initial condition is of an oxidative nature, though deprival of oxygen does not immediately cause it to fail. Apparently the nerve possesses, maybe as a safeguard against asphyxiation, a store of oxygen in some form other than molecular. A nerve may go on functioning and carrying out its usual recovery for hours, or even days (depending on the temperature) before all its oxygen store is used up. Then, and only then, it fails. If a nerve asphyxiated by lack of oxygen is given oxygen once more, recovery rapidly occurs and excitability returns.

Other Effects of Oxygen

The difference of potential between an injured and an uninjured point of a crab's nerve is maintained for a long time in the presence of oxygen and the absence of stimulation. Stimulation rapidly reduces it, so to speak 'depolarises' the nerve surface. The potential rises again to its full value if, and only if, oxygen be present. In the absence of oxygen it falls still further. The potential difference across the surface of a nerve depends for its maintenance on the continued presence of oxygen.

Stimulation and lack of oxygen, however, are not the only means by which the potential difference can be reduced. There is normally a ratio of about 10 to 1 between the inside and the outside of a crab's nerve fibre in respect of potassium ion concentration. If we suppose that potassium is the only substance capable of penetrating the fibre surface of the crab's nerve, then this concentration ratio should lead to a potential difference of $\frac{RT}{F} \log_e 10$ which is about 58 mv. Values of 30 mv. in freshly dissected nerve are commonly observed, and sometimes more, and since a certain amount of short-circuiting must occur in the strongly conducting fluid between the fibres, the real value may well approximate to the 58 mv. required by the formula. If the hypothesis is right, the potential difference would be reduced by increasing the potassium ion concentration on the outside of the fibre. Cowan has found this to be the case. By soaking a nerve for a few seconds in sea-water to which potassium has been added, the potential difference may be varied from 30 mv. or 40 mv. down to nearly nothing as desired. The potential difference is clearly determined by the potassium ion concentration, and yet it is dependent also on the presence of oxygen. This paradoxical dependence on two such different factors has not yet been resolved: perhaps the oxygen is used in maintaining the normal properties of the surface membrane.

Another, and a most curious effect of oxygen, has recently been observed in the action of veratrine, a plant alkaloid, on frog's nerve. Applied to a muscle, this drug causes a prolonged response to a single impulse: applied to a nerve it has little effect, the action current is not greatly lengthened, the heat production is not largely increased, by soaking the frog's nerve for an hour in 1 in 50,000 veratrine solution. If, however, after the nerve has been soaked it be then asphyxiated for three or four hours until it is completely inexcitable, and if it be then revived by admitting oxygen, it shows in a striking manner a typical veratrine effect. The action current lasts hundreds of times as long, the heat production is thousands of times as great, as in the normal response of a nerve to a single shock.

Apparently the drug is usually unable to penetrate the nerve fibre sheath. When, however, the nerve has been asphyxiated, the condition of the surface has somehow been altered so that the substance which was previously held out is now able to penetrate. Oxygen is necessary for the maintenance of the normal impenetrable condition of the surface of the fibre. One naturally associated this effect with the presence of a thick sheath around the axis cylinder, and asked whether the veratrine effect could be manifested in other nerves in which no medullary sheath is present. The experiment was made by Cowan, and showed that in crab's nerve a typical veratrine effect is produced without any asphyxiation, and that the concentration of the drug required is only one thousandth of that for frog's nerve. Veratrine apparently can penetrate normally the very thin surface of a non-medullated nerve, but it is held out almost indefinitely, until the nerve is asphyxiated, by the sheath normally covering the axis cylinder of a medullated nerve.

This strange result suggested that the effect of curare should be similarly tested. Curare paralyses a muscle, in respect of impulses coming to it along its motor nerve. It was formerly thought to attack the neuro-muscular junction, though recently, on the strength of Lapicque's theories, it has been supposed to produce its effect by changing the 'time scale of excitation' of the muscle fibre, putting it out of tune so to speak with its nerve. Recent work by Rushton has shown that this hypothesis of Lapicque's is untenable, so that the manner of action of the drug was still unsolved. It was possible that curare might be a potent nerve poison but normally unable to penetrate except at the neuro-muscular junction. At this point the medullary sheath is absent. Perhaps a nerve dosed with curare but apparently unaffected, might be found effectively poisoned after asphyxiation.

The experiment was performed by Fromherz: a muscle nerve preparation was paralysed by soaking in curare, the nerve was removed and still showed a normal action current: it was then asphyxiated in hydrogen and after asphyxiation allowed to recover (if it could) in oxygen. An unpoisoned nerve treated in this way immediately gives a large action current on readmission of oxygen. The curarised nerve gave only a small one and recovered very slowly. Curare, there-

fore, may render a nerve incapable of responding, once it is able—as during a state of asphyxia—to get in. This may be the solution of the problem: the effect of curare is not on the 'chronaxie' of muscle, but on the part of the nerve which is exposed to the action of the drug, namely, its ending where the medullary sheath is absent.

Time Relations of Excitation

All living animals, organs, or organisms, have a certain characteristic scale of time. The fibres of the wing muscle of a fly can contract hundreds of times a second, those of the leg muscle of the tortoise, differing from the fly's in no other very obvious way, may take several seconds to give a single twitch. The mouse and the man differ greatly in many of their characters and the difference is largely that of the scale of time on which respectively they live. This difference of time scale is a necessary accompaniment of a difference of size: a very small motor may do 10,000 revolutions per minute, a large one must be content with a few hundreds. One of the most important problems of physiology, and it is a problem of general, almost of philosophical interest, is what determines the scale of time of an animal or cell.

In nerve, the time required at any point for the action current to go through its cycle, the time taken in the transmission of the impulse, and the time-scale (to which I will refer later) of electric excitation, all can be varied together as we alter the condition of the cell or pass from one cell to another. These are different aspects of the same phenomenon—the transmission of the impulse. At the end of the last century it was shown by Waller, employing stimulation by condenser discharge, that there is an 'optimal' stimulus for any given tissue, in the sense that the energy in it is a minimum. He showed, and Keith Lucas following him showed, that the effectiveness of a condenser stimulus of given energy depends upon the rate of discharge of the condenser. If F be the capacity and R the resistance through which discharge takes place, the time of discharge is proportional to the product FR, and for given energy $\frac{1}{2}FV^2$ in the stimulus, the response depends on the product FR.

The use of condensers is very convenient and is generally adopted in studying the time relations of the excitatory process. The relation, however, is clearer if excitation be produced with the aid of a constant current of variable duration. If a constant current be led into an excitable tissue by two non-polarisable electrodes, in order that a stimulus of very short duration may be effective its intensity must be great, while if it lasts for a long time its intensity may be small. In the case of medullated nerve the times involved are very short, so that rather special methods of determining the duration of the constant current employed must be adopted. The relation between the duration of a constant current and the least strength required for excitation (the so-called strength-duration curve) is shown in Fig. 1.

In the case of nerve this curve is always approximately of the same form and may be defined by two parameters, the scale of time and the scale of current. The latter is of no particular interest, since most of the current is short-circuited in the fluids between the excitable elements and no strictly standard conditions for comparison can be defined. The scale of time, however, *is* important, and is very constant for a given nerve under given conditions, and the usual method of expressing it is by means of the minimum duration of a current of twice the threshold strength. This duration was called by Keith Lucas the 'excitation time' and by Lapicque the 'chronaxie', the latter term in its derivation meaning no more than the time scale of the process or tissue in question.

The excitation time of nerve depends upon many factors: (*a*) the nature of the nerve itself; it varies greatly from one fibre to another, in the same kind of way as the velocity of propagation of the impulse referred to earlier; (*b*) it is increased by a fall, decreased by a rise of temperature; (*c*) it is considerably affected by the nature of the ionic constituents in the solution around the nerve, particularly by the concentration of the calcium, and to a less extent of the potassium ion; (*d*) it depends upon the size of the fibre, being smaller in a fibre of greater diameter.

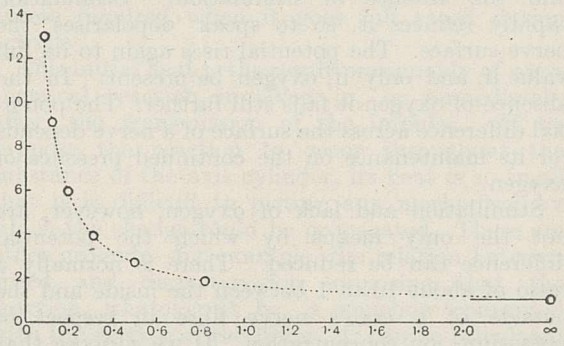

Fig. 1.

"Strength duration curve" for nerve excitation. Horizontally, duration in σ (0·001 sec.); vertically, minimum strength required.—From "Chemical Wave Transmission in Nerve", by A. V. Hill (Cambridge University Press, 1932).

The form of the strength-duration curve leads us to a discussion of the nature of electrical excitation. A constant current passed through an excitable tissue excites twice, once at the cathode at make, once at the anode at break. Unless the current be too strong, when secondary effects (for example, electrolysis and polarisation) occur, no propagated impulse is started off during the passage of a constant current. With an alternating current, however, of not too high a frequency the case is different. An impulse starts off from the cathode for each positive phase of the current, another from the anode for each negative phase. This is true up to, say, 300 a second for a frog's nerve, 700 a second for a mammalian nerve. When, however,

we consider the case of a much higher frequency, say, of 100,000 to 1,000,000 per second, a different result is found. Such currents produce no response even though they be so strong that considerable warming occurs. This is commonly imagined to be due to the so-called 'skin effect', but it can readily be shown that with the high specific resistance of living tissues the skin effect does not come in until a frequency is reached far higher than that we are considering.

Let us suppose that excitation occurs, that an impulse is started, when the current outwards through the sheath of a nerve fibre in the region of the cathode attains more than a certain density (Fig. 2). When the outward current is large enough something is rendered unstable, and the state of instability is propagated as a wave. We suppose that the sheath of a fibre possesses the properties of a dielectric of high but not infinite specific

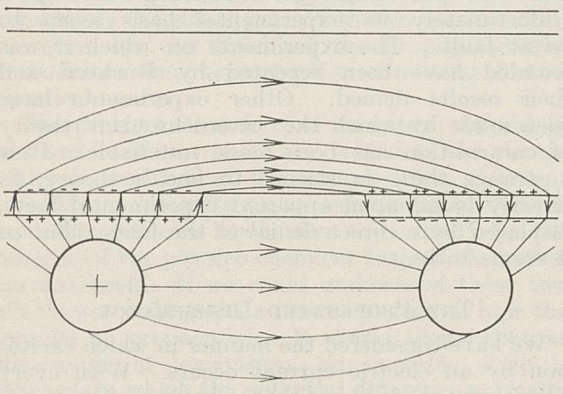

FIG. 2.

Nerve fibre with two electrodes; current flow outside, inside and through sheath.

resistance. The first effect of a difference of potential applied along the nerve is to charge the capacities at the anode and the cathode. The nerve, in fact, acts like a cylindrical condenser, the sheath being the dielectric between the plates.

When an alternating current of high frequency is applied between electrodes resting on the nerve the effect of each cycle is to charge, alternately in opposite directions, the condensers lying near the electrodes. Unless the current be very strong, these condensers absorb it and prevent a potential difference from arising across the dielectric of sufficient intensity to drive any considerable current through the latter. With a lower frequency, however, or with a constant current, while the first effect is still to charge the condensers, as these are charged a difference of potential arises across the dielectric by which a current is caused to pass. When this current reaches a sufficiently high density outwards at the cathode, instability is produced and excitation occurs.

With constant currents, the shorter the duration the greater the current has to be to produce an excitatory effect. With a current of great duration the capacities in the surface of the fibre have ultimately no influence. With very short durations, however, the first effect is to charge the condensers and so to reduce the E.M.F.'s available across the dielectric. If then the applied current is cut off before the condensers are charged, the potential difference across it will be less than that which would ultimately be attained, and for excitation to occur the applied E.M.F. must be greater.

From this model an equation for the strength-duration curve can be deduced as follows:

$$C = \frac{R}{1-e^{-t/\frac{Fr\,(r_o+r_i)}{2r+r_o+r_i}}}$$

Here C is the current, t its duration, R a constant, F the capacity and r the resistance per sq. cm. of the sheath in the neighbourhood of the electrodes, r_i the resistance of the inside, r_o that of the fluids on the outside, of the nerve between the electrodes.

For the case of electrodes very far apart where $(r_o + r_i)$ is large compared with r, this equation approximates to

$$C = \frac{R}{1-e^{-t/Fr}}$$

The important term in deciding the form of the relation is the product Fr, which is obtained by multiplying together the capacity and the resistance per square centimetre of the surface of the fibre. The relation experimentally observed in the strength-duration curve (Fig. 1) is fitted with sufficient accuracy by this equation.

If the excitation time be determined by the product of the capacity and the resistance per square centimetre of nerve fibre surface, then we should seek to explain the differences between different fibres, or between the same fibre under different conditions, by changes in the product Fr. The thinner the sheath the greater will F be, and the greater the excitation time: the lower the resistance, the shorter will be the excitation time. A rise of temperature presumably alters the excitation time by diminishing r. The absence of calcium causes a large increase in the excitation time, possibly through an increase in the resistance of the surface of the nerve. Such a change of resistance might be brought about by an alteration in the state of the emulsion of oil in water, or water in oil, of which it is possible that the sheath of the nerve is composed.

There are complications, however, in this story. It seems certain that the potassium ion has some specific function in determining the potential difference which exists between the inside and outside of a fibre and the action current by which the wave is propagated. Possibly potassium has some specific solubility in the lipoidal substances of the nerve sheath, some specific power of penetrating which other ions have not. The current outward at the cathode by which we suppose excitation to occur is probably carried by potassium ions.

This may explain a phenomenon on which I have not yet touched, that of the gradual adaptation to a slowly increasing current. It has long been known that a current which would normally be strong enough to produce excitation may not do so if its full value be reached not suddenly but slowly. If potassium be the only means of carrying current through the sheath, its continued transfer outwards at the cathode would have the effect of depleting the inside and raising its concentration on the outside, so that a back E.M.F. would be generated (determined by $\frac{RT}{F} \log \frac{C_2}{C_1}$): this might effectively prevent the further transfer of current at a time when the externally applied E.M.F. at last reached the value at which, if suddenly applied, it would excite.

Similarly, we may explain the stimulus occurring at the anode at break of a long-continued constant current. During the prolonged passage of the current the potassium ions on the outside at the anode have been depleted by carriage through the sheath until either so few are available, or the back E.M.F. is so great, that no current can run. Breaking the circuit of the applied E.M.F., the constraint at the anode is released, the unusually high ratio (potassium inside) : (potassium outside) immediately tends to right itself by the back transfer of potassium ions outwards through the membrane. This constitutes a current similar to that which occurs normally at excitation at the cathode; consequently, when the back rush of potassium ions is rapid enough, excitation occurs and an impulse starts off.

The normal function of motor nerves is to transmit impulses to the muscles, and for many years physiologists have discussed how the impulse in the nerve gets across to, and produces its effect in, the muscle fibre. Motor end-plates have been described by histologists, but their functions, and even their existence, are doubtful. It has been supposed that the electric change in the nerve which is an accompaniment of the impulse, starts the process of excitation in the muscle fibres, just as in the laboratory an impulse is started by an electric shock. This idea has led to the view that the muscle fibre and its motor nerve are normally 'isochronous', that is to say, have the same 'excitation time'; a muscle was supposed to respond to the impulse in a nerve if the latter was in tune with it, but not otherwise.

Some years before the War, Keith Lucas showed that in muscle there are two different excitable substances which he supposed were the muscle fibres themselves and the nerve twigs running to them. Lucas's experimental demonstration was denied by Lapicque who, employing different electrodes, found that the excitation time of both tissues was the same. Lucas's observations, however, have been reinstated by Rushton, and it seems doubtful whether Lapicque's claim of normal isochronism between muscle and nerve can stand. The most beautiful application of Lapicque's theory, one which was perhaps just a little too convincing because of its beauty and because it appeared to explain so much, was that of the mechanism by which paralysis is caused by curare or other drugs or by such agencies as fatigue. Normally, the impulse from the nerve passes over into the muscle. A small dose, however, of curare, or the onset of fatigue, somehow breaks the connexion, and Lapicque maintained that this was due to the fact that the curare, or the other paralysing agency, had increased the excitation time of the muscle fibre until it was no longer isochronous with its motor nerve and therefore the impulse from the latter failed to affect it. The case was like that of two tuned electric circuits, sending and receiving—if the receiver were put out of tune with the transmitter, messages were not received.

Various experiments were adduced in support of this theory, and for a time it was accepted and was in danger of becoming a dogma. Unfortunately its experimental basis seems to be at fault. The experiments on which it was founded have been repeated by Rushton and their results denied. Other experiments have been made by which the 'heterochronism' theory of curarisation has been made untenable. It is a strange thing in science to find a theory, so directly based upon apparent experimental facts, displaced by a direct denial of the facts: but so it seems to be.

The Propagated Disturbance

We have considered the manner in which excitation by an electric current occurs. With every adjustment made to get the most efficient stimulus, the energy in it is still very large when compared with that set free by the nerve itself as an impulse runs along it. Electrical stimulation is very wasteful compared with the natural stimulation from point to point by which an impulse is propagated. This is not difficult to understand. The chief part of the energy of an artificial stimulus is wasted in the fluid between the electrodes outside the active region of the nerve fibres. Only that fraction of the current which, according to our hypothesis, crosses the cathode region of the surface, is effective as a stimulus. In natural stimulation, that is from point to point in the propagation of the wave, there are no electrodes and there can be no short-circuiting in the different fluids: the stimulating current, therefore (if propagation be by means of the current), is far more efficiently used.

There is a tendency to assume, as I have assumed here, that propagation of the impulse from point to point occurs through the agency of the action current which can be detected at an active point. There is no doubt that the action current has the time relations of an efficient stimulus and, properly applied, it should have the magnitude requisite for excitation. We have no picture of the manner in which the excitatory disturbance is propagated, except that which supposes that the action current at any given point 'stimulates' a

neighbouring point, where in its turn a further action current is produced, which again stimulates a neighbouring point, and so on. The fact that the velocity of propagation runs parallel with the speed of development of the action current at a given point, and also inversely with the time scale of the process of excitation, strongly suggests that these three factors are linked together in some relation of cause and effect.

It must not be imagined that this self-perpetuating electro-chemical wave is analogous to those waves in physics in which no new energy is required from point to point for the transfer of the wave. In sound, or in light, energy is forced into the medium at the source but no further energy is required for the propagation. Unquestionably in nerve, as the initial heat shows, energy is liberated at each point as the impulse passes by, and, moreover, in the next thirty or forty minutes several times as much energy is set free in restoring completely the *status quo*. With this qualification, however, we can think of the propagated disturbance as some type of self-transmitting electro-chemical wave.

The problem, therefore, of its nature ultimately resolves itself into two : one is that of the change which is produced at the cathode when a current of sufficient intensity causes conditions to become unstable and some mechanism to be fired off ; the other is of the physico-chemical basis of the action current itself. If we could understand these two effects we could make a clearer picture of how the impulse is propagated. It seems likely that as the result of 'excitation' an unstable state is reached, in which the potential difference normally held at the surface of the fibre is for a moment released. It discharges until some change sets in by which the instability is reversed and the initial condition realised once more. Looked at in this way, the action current is nothing more than a momentary discharge of the resting potential, which is normally to be seen between an injured and an uninjured point of a nerve. Our problem, therefore, comes to this, what is the nature of the instability which is produced by a sufficient outward current through the nerve surface, and how is this instability rapidly reversed and the nerve surface restored to its normal state ?

The chemical reactions occurring in muscle are largely those of recovery. Lactic acid formation is involved in the restoration of creatine phosphoric acid which breaks down in activity ; oxidation and the combustion of food-stuffs are involved in the restoration of the lactic acid. In nerve we know that in any case nine-tenths of the energy liberated is involved in recovery. It is not going very much further to suppose that the remaining tenth is involved in the immediate recovery process by which the instability produced by stimulation is reversed. I should picture the primary effect as a physico-chemical one transmitting itself along the surface. The surface is rendered somehow unstable by the passage of a current outwards across it, and the instability is propagated by means of the current it releases. The return of the surface to its normal state is the result of some chemical reaction involving the liberation of free energy. Without this return no further impulse could be propagated.

Mitogenetic Radiation in Nerve

The facts I have described so far are reasonably certain, though their explanation is not. I wish now shortly to refer to some others, of great importance if they are confirmed, but of which the evidence is as yet not quite convincing. During the last few years a number of papers have appeared from Moscow and Leningrad on the subject of so-called 'mitogenetic radiation'. The name implies that the radiation in question is able to cause mitosis in cells, and the approved method of detecting and measuring it is to determine the increase in the number of yeast cells in a suspension subjected to the radiation. Living organisms themselves are said to give out this radiation, particularly when active, and the analysis of the radiation is held to indicate the type of chemical reaction involved in the activity.

The yeast cells prepared in a special manner are held in a suspension which is placed in two tubes, an experimental and a control. The experimental tube is exposed through its open end to the radiation in question, the control is kept without radiation. At the end of the exposure, samples are taken and incubated, and after three or four hours the cells are killed and counted ; the excess of cells in the experimental suspension is expressed as a percentage of the control.

The radiation stated to be given out by living cells is in the ultra-violet region, chiefly between 1900 A. and 2500 A. Its amount is so relatively large that it can be split up by a quartz spectrograph into bands 10 A. wide and each band examined separately for its effect in producing the division of yeast cells.

This is not the occasion to deal with the general question of mitogenetic radiation, but a few months ago a series of papers appeared from the laboratory in Leningrad in which various results obtained from nerve are discussed. If it be true that excited nerve gives out a characteristic radiation which can be used to identify the chemical reactions involved in its activity, then indeed a new day has dawned in the very difficult problem of the physical nature of nerve activity.

In a figure in a recent paper by Kalendaroff (*Pflügers Arch.*, 231), successive spectra, analysed by a quartz spectrograph and the yeast cell indicator, refer to (1) a resting nerve, (2) ground up nerve, (3) mechanical stimulus, radiation from the point of stimulation, (4) electrical stimulus, between the electrodes, (5) injury, radiation 20 mm. from the place of injury, (6) electrical stimulus, radiation 20 mm. away, (7) mechanical stimulus, 20 mm. away. In the lower half of the figure there are spectra for (1) oxidation of pyrogallol

in air, (2) glycolysis, (3) action of phosphatase, (4) splitting of creatine-phosphoric acid, (5) splitting off of ammonia from protein.

When we remember that maximal continuous stimulation of nerve does not double its resting metabolism, the variety and strength of the radiation emitted from active nerve, under the comparatively mild stimuli administered to it, are rather astonishing. A vague suspicion that the results are almost too good to be true is a little increased by a subsequent paper by Schamarina which shows an evident misunderstanding of the nature of nerve activity. It is known, and it is an obvious consequence of the existence of a refractory period following the passage of an impulse, that when two nerve impulses start at opposite ends of a nerve and meet in the middle they are unable to pass one another and both are wiped out. When a single impulse traverses the nerve the whole of the nerve goes through a phase of activity. When two impulses start at opposite ends of the nerve they meet in the middle and stop, but again the whole of the nerve has gone through the active phase. If radiation is given out as the result of nerve activity, its emission should occur equally in the two cases. Schamarina, however, expecting that because the two impulses destroy one another, therefore there should be no radiation from the point where they meet, has described experiments in support of the expectation. If the results are true, we need a new picture of the propagated disturbance in nerve.

The suspicion is strengthened by a further paper by Brainess describing the use of the same technique for the study of human fatigue. At the beginning of this remarkable paper it is stated that modern methods for investigating the phenomena of fatigue in man leave much to be desired, and that the author therefore took up the method of mitogenetic radiation in order to find a new and more accurate means of describing the state of fatigue in a factory worker. One hundred girls working in an electrical factory were examined, samples of their blood being taken at eight in the morning, at three in the afternoon and at five in the afternoon. The blood was dried on filter paper, then dissolved in distilled water and finally allowed to give out its radiation, which was measured as usual by the yeast cells. At eight in the morning the mean value of the radiation coming from their blood was 28, as measured by the percentage increase, over the control, of the number of cells in the yeast suspension. After seven hours work the girls were apparently completely exhausted, for their blood gave out no radiation at all, except in a few isolated cases. After two hours rest the radiation had risen to 28 again.

Of the social and industrial importance of these results, supposing them to be true, I need not speak, though I wonder if there are many British factory operatives who would be found completely exhausted, even of 'radiation', after seven hours work. An even stranger result follows. Not only did hæmolysed blood emit radiation which was abolished by seven hours work in a factory, but also the cornea and the conjunctiva did the same. The girls apparently had only to look at the yeast cells to set them dividing! At eight in the morning the radiation from the girls' eyes had a mean value of 24, after seven hours work it had a mean value of 4, after two hours recovery a mean value of 20. Finally—and most unromantically—it is stated that the spectrum analysis of the radiation given out by the girls' eyes showed that its only important component is that due to glycolysis!

It is not easy, in the case of the paper describing the results of the two nerve impulses meeting one another, to avoid the feeling that the expectation of a certain result has had something to do with its appearance, and it is difficult not to draw the same conclusion from the paper describing the new test for fatigue. The claims made are clearly most important if they can be verified, and one hopes that verification may soon be at hand. The difficulty in understanding nerve is largely that the changes in it are too small for ordinary chemical methods to detect. If the new methods elaborated by our Russian colleagues can throw real light on the subject, then we shall be deeply indeed in their debt. At present, however, one cannot stifle suspicion that the phenomena described may have more to do with the enthusiasm of those who describe them than with the physical nature of the nerve itself.

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A grant has been received also from the International Cancer Research Foundation, an organisation established last year in Philadelphia by Mr. William H. Donner and endowed by him with a sum of 2,000,000 dollars. Although its administrative headquarters are situated in America, the Foundation is world-wide in its scope. The income of the fund is to be applied to assist research into the causes, prevention, control, relief and cure of cancer, and this income is to be so distributed that not less than 35 per cent nor more than 50 per cent is to be allotted in countries other than the United States. The trustees have awarded a sum of £1,000 a year for a period of two years to the Cancer Hospital Research Institute in support of investigations into factors which underlie the origin of malignant growths. This sum will provide two research studentships, to one of which Mr. G. A. D. Haslewood has been appointed. The two research students will undertake the investigations of special problems in connexion with the general scheme of research now in progress at the Cancer Hospital.

Protection against Lightning

WE welcome the handbook entitled "Code for Protection against Lightning", a revised edition of which has just been published (U.S. Government Printing Office, Washington, 1933, 15 cents). The number of fatalities from lightning in the United States is insignificant in comparison with the 100,000 annually from all other accidental causes. But the suddenness with which the flash happens, and the apparent impossibility of telling where it may strike next, may well frighten the bravest. Directions are therefore given for personal conduct during thunderstorms. If it is necessary to be out of doors, it is desirable to keep away from small sheds in exposed localities, isolated trees, wire fences, hilltops and wide open spaces. Shelter can be sought in a cave, a depression in the ground, a deep valley, at the foot of a steep or overhung cliff or in a grove of trees. Best of all is to stay indoors and keep away from fireplaces, stoves and all other large metal objects. Modern buildings are safe because of the protective effects of the metal used in constructing them and the metal piping on the exterior walls. The rules for erecting lightning conductors are now practically standardised. An approved protector should be placed as near as practicable to the point of entrance of an aerial telephone wire into a building. Metal radio masts should be bonded to the nearest lightning conductor. Wooden radio masts which extend six feet or so above the highest parts of the building should be provided with a connexion to earth. In an appendix, various kinds of lightning phenomena are described and modern theories are explained. A very instructive map is given showing the average number of days on which thunderstorms occur at many stations in the United States and Canada. There are very few thunderstorms on the Pacific Coast but at Tampa in Florida the number of days per annum on which thunderstorms occur is 94.

Archæological Exploration in Oaxaca, Mexico

RECENT reports received by Science Service, Washington, D.C., from Miss Emma Reh, who is engaged in archæological exploration in Mexico, point to the possibility of further discoveries bearing on the problem of the position of Mixtec culture and the area now known as the province of Oaxaca as a connecting link between the Mayan culture to the south and Mexican culture to the north. It will be remembered that this was the problem on which S. Alfonso Caso was engaged at the time he discovered the treasure tomb of Monte Alban a year ago. Miss Reh has recently examined the sites of two ruined cities in the mountainous Mixteca area, Teposcolula and Hualmelulpan, situated eighteen miles apart, neither of which had previously been recorded on the official archæological map of Mexico. Hualmelulpan was an important centre which once dominated the road from north to south. In the inner of two pyramids, built one over the other, Indians have found a number of sculptures and idols. Among them Miss Reh reports a sculptured slab which bears the date "Thirteen Stone Knife" in the Mayan numeral system, constituting an important link with the Mayan culture to the south. Among other material is a human figure more than six feet high carved from stone, which shows a snarling mouth armed with formidable fangs. This may be the ancient Mixtec deity Tepeyolotl, "Heart of the Mountains", often represented as a tiger. Pottery heads found on the mounds and terraces range in series extending from 'Mixtecan' to 'archaic'.

Accommodation for Paying Patients at Voluntary Hospitals

THERE is a growing demand for nursing accommodation for those who, unable to pay the charges of a nursing home, desire better accommodation or more privacy than is provided in ordinary hospital wards and are willing to pay for it. King Edward's Hospital Fund for London has therefore issued a list of the 'pay beds' at hospitals making returns to the King's Fund, with particulars of the accommodation and of the normal weekly charge. The pamphlet may be obtained from the Fund, 7 Walbrook, E.C.4, price 3*d*. including postage.

Health of the British Army during 1931

IN the report on the health of the army for the year 1931 (H.M. Stationery Office. 2*s*. 6*d*. net), the Director-General, Lieut.-Gen. Fawcus, states that the health of all ranks both at home and abroad was satisfactory. With an average strength of 181,508, the principal causes of admission to hospital were influenza, malaria, and venereal diseases, with 8,324, 7,191, and 5,865 cases respectively. Tonsilitis accounts for 5,752 cases, a decrease over the previous year. Dysentery has increased somewhat. Venereal diseases have shown an almost steady fall during the last ten years, from 70 per 1,000 strength in 1922 to 33 per 1,000 in 1931.

Californian Earthquake of March 10

LATER accounts of this earthquake show that, though stronger than the Santa Barbara earthquake

of 1925, it is not to be numbered among the great earthquakes of California. The epicentre is placed by the U.S. Coast and Geodetic Survey in lat. 33·7° N., long. 118·9° W., a point in the San Pedro channel, about twenty-five miles west of San Pedro Point (Science Service, Washington, D.C., March 11). The earthquake was thus probably due to a movement along the submarine San Pedro fault zone. The earthquake of July 28, 1769, also seems to have been felt most severely along the shore of San Pedro Bay and may therefore have been connected with the same fault zone.

Plastic Materials

Although a large number of new industries dealing with the products of plastic materials have been established in recent years, it is not yet realised the extent to which these 'substitute' materials have nowadays replaced natural products. In order to introduce plastic materials to other industries, as well as to the public, an exhibition was opened by Lord Irwin at the Science Museum, South Kensington, on April 5, which traces the course of the plastics industry from the various raw materials used in the production of plastics to the final product of artificial wood, china, horn and metals. Natural and synthetic resins, cellulose and casein are the principal bases on which the new industries depend and from these has been built up a wide variety of manufactures, ranging from aircraft accessories, buttons, dental instruments, electric insulation, fancy goods, furniture, gramophone records, combs, spectacle cases to scientific instruments and such sports requisites as golf balls and billiard balls. The term 'plastic materials' covers a number of natural and artificial chemical products, the chief property of which is that they can take shape or form under pressure. One of the most interesting features of the exhibition is a room in which the furniture and the surfaces are made entirely of plastic materials. The exhibition will remain open until the end of September.

Announcements

Wing-Comdr. The Hon. Maurice Baring, Prof. W. Langdon Brown, Regius professor of physic in the University of Cambridge, and Prof. H. H. Dodwell, professor of history of the British Dominions in Asia, School of Oriental Studies, have been elected members of the Athenæum Club under the provisions of Rule II of the Club, which empowers the annual election by the committee of a certain number of persons of distinguished eminence in science, literature, the arts, or for public service.

Prof. H. E. Armstrong will deliver the Huxley Memorial Lecture at the Imperial College of Science and Technology, South Kensington, on Thursday, May 4, at 5.30 p.m. His subject will be "Our Need to Honour Huxley's Will".

A David Anderson-Berry gold medal, together with a sum of money amounting to about £100, will be awarded in July 1935 by the Royal Society of Edinburgh to the person who, in the opinion of the Council, has recently produced the best work on the nature of X-rays in their therapeutical effect on human diseases. A similar award will be made every three years.

M. Albert Portevin, president of the Société des Ingénieurs Civils de France, will deliver the twenty-third annual May lecture before the Institute of Metals at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W.1, on May 10, at 8 p.m. The subject of the lecture will be "Quenching and Tempering Phenomena in Alloys".

Silver medals of the Royal Aeronautical Society have been awarded to Mr. D. L. H. Williams for his work in designing the Fairey long-range monoplane in which Squadron Leader Gayford and Flight Lieutenant Nicholetts made a record non-stop flight to South Africa, and to Mr. A. H. R. Fedden for his work on air-cooled engines, particularly the Bristol Pegasus engine used in the biplane in which Mr. C. F. Uwins recently attained a height of 43,976 ft.

At the annual general meeting of the Physical Society held on March 17 the following officers were elected: —*President*, Prof. A. O. Rankine; *Vice-President*, Prof. W. Wilson; *Secretaries*, Dr. Allan Ferguson (Papers), Dr. Ezer Griffiths (Business); *Foreign Secretary*, Prof. O. W. Richardson; *Treasurer*, Mr. R. S. Whipple; *Librarian*, Dr. J. H. Brinkworth; *New Members of Council*, Prof. E. V. Appleton, Dr. L. F. Bates, Dr. L. Hartshorn.

At the annual corporate meeting of the Institution of Chemical Engineers, held on February 17, the following officers were elected: *President*, The Right Hon. the Viscount Leverhulme; *Vice-Presidents*, Dr. H. Levinstein, Mr. H. Talbot; *Hon. Secretary*, Mr. H. W. Cremer; *Hon. Treasurer*, Mr. F. A. Greene; *Members of Council*, Col. E. Briggs, Mr. H. J. Pooley, Dr. F. S. Sinnatt; *Associate-Members*, Mr. C. C. H. Brazier, Mr. H. A. S. Gothard. The Osborne Reynolds medal for the year 1932 was presented to Mr. S. G. M. Ure, in recognition of his valuable services to the Institution as honorary editor of the *Transactions* for the past seven years. The Moulton medal for the best paper read before the Institution during the year was awarded to Dr. C. M. White, for a paper entitled "Fluid Friction and its Relation to Heat Transfer", and the Junior Moulton medal and prize of books was awarded to Dr. W. B. Hawes for a paper entitled "Some Sidelights on the Heat Transfer Problem".

Applications are invited for the following appointments, on or before the dates mentioned:—A staff lecturer at the Northern Counties Training College of Domestic Science, Northumberland Road, Newcastle-upon-Tyne—The Principal (April 10). A head of the mechanical engineering department of Rutherford Technical College—The Director of Education, Education Office, Northumberland Road, Newcastle-upon-Tyne (April 22).

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.*]

Spectrum and Latitude Variation of Penetrating Radiation

I HAVE made some calculations on the spectrum and latitude variation of penetrating radiation on the assumption that it consists of electrons coming to the earth from outside.

If we assume that the electrons are incident on the atmosphere uniformly in all directions, it may be shown that the number of incident electrons with a range R, is proportional to the value of xd^2I/dx^2 at a depth $x = R$. I denotes the intensity of ionisation at a depth x, the latter and the range R being measured in terms of distances travelled in a homogeneous medium. The derivation of this relation, and the exact conditions of its applicability, will be given elsewhere. By means of it, and also the relation between range and energy, we can deduce the energy spectrum of the incident electrons directly from the ionisation-depth variation.

The distribution of the electrons responsible for the ionisation at any given depth may be obtained from the distribution of the incident electrons by allowing for the absorption by the superincumbent matter. The curve in Fig. 1 represents the results obtained in this way for the incident energy spectrum (averaged over all directions) of the electrons responsible for the ionisation at sea level (76 cm. pressure).

These results depend upon the assumption that the electrons are incident on the atmosphere isotropically. The fact that the ionisation due to penetrating radiation is independent of the time, proves that the distribution of the electrons in outer space is isotropic. This is not necessarily the case at the surface of the earth, on account of the effect of the earth's magnetic field. The latter effect has been recently investigated in detail by Lemaître and Vallarta[1]. They find that for electrons of a given energy there exists a latitude, λ, above which the distribution of the electrons at the earth's surface is

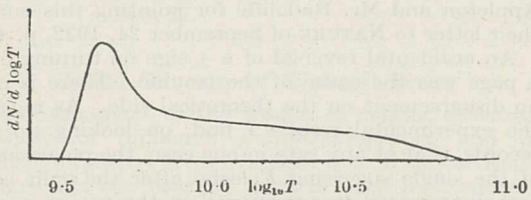

FIG. 1.—Distribution of incident energies of electrons responsible for sea level ionisation. T = energy in volts.

not at all affected by the earth's magnetic field, and is therefore isotropic. The value, λ_m, of λ, corresponding to the minimum energy, T_m, which an electron must have in order to reach sea level, is about 50°. The ionisation-depth data used here were obtained in experiments made in higher latitudes than this. It follows that the results represented by the curve in Fig. 1 are not invalidated by the assumption of isotropic incidence.

For latitudes $<\lambda_m$, electrons with $T>T_m$, that is, electrons with sufficient energy to reach sea-level in certain directions, are not all incident isotropically. Certain directions of incidence for certain energies are disallowed. The sea level ionisation in these cases is obtained by considering the absorbing effect of the atmosphere on the electrons incident in the allowed directions. Using the numerical results for these allowed directions given by Lemaître and Vallarta, we obtain in this way curve A, (Fig. 2), for the variation of sea level ionisation with magnetic latitude*.

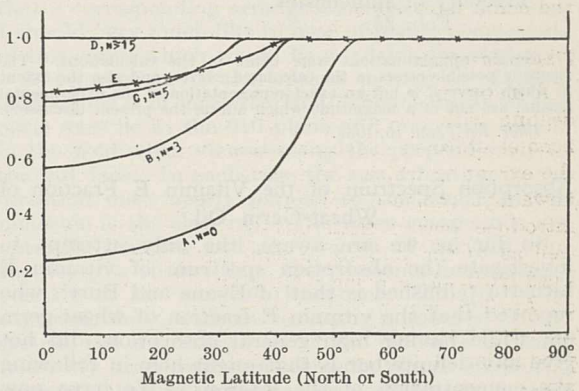

FIG. 2.—Variation of sea level ionisation with latitude. Value at poles taken as unity for calculated curves. Value at highest latitude investigated taken as unity for experimental curve.

The requirements that the falling off in the ionisation, as the equator is approached, should start suddenly at a certain latitude, and also be symmetrical about the equator, satisfies the outstanding features of the experimental results. The latter are represented in Fig. 2 by curve E (marked with crosses). This agreement makes it almost certain that at least part of penetrating radiation is due to the existence of an isotropic distribution of high-energy electrons in outer space. The existence of a fairly critical latitude arises from the calculations by virtue of, (*a*) the above result obtained by Lemaître and Vallarta that for electrons of a given energy there is no effect on their distribution at the surface of the earth above a certain latitude, (*b*) the result that the energy spectrum of the electrons concerned starts suddenly at a certain energy.

The quantitative discrepancy between curves A and E indicates either an admixture of photons, or a greater rate of dissipation of energy by the electrons than is attributed to them in the calculations. In the calculations leading to A, it is assumed that the penetrating electrons interact only with the extra-nuclear electrons of the matter traversed, and that this interaction obeys quantum mechanics. There is, however, definite experimental evidence for nuclear interaction. Assuming that the latter gives rise to a stopping-power n times the theoretical value due to extra-nuclear interaction, we obtain curve B for $n=3$, and curve C for $n=5$. If the nuclear effect consists in the ejection from the nucleus of high-energy electrons and protons, which acquire their energy from the primary electron, then n roughly represents the average number of particles in equilibrium with one primary electron. The frequent occurrence of groups of two or more associated tracks within the relatively small dimensions of a Wilson cloud chamber, indicates that $n\sim5$ is not improbable.

The correction to the spectrum in Fig. 1 due to the above nuclear effect consists in a lateral displacement of the curve by $+\log_{10} n$. As regards the spectrum of all the ionising particles at sea level, which have energies greater than 10^7 volts, a value of $n=5$ requires about 10 per cent of them to have energies greater than 10^{10} volts, and 2 per cent to have energies greater than 10^{11} volts. These estimates assume that the secondary particles have energies between 10^7 and 10^{10} volts.

E. J. Williams.

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University of Manchester.
Feb. 25.

* Certain approximations were made in the calculations. The resulting possible errors in the calculated curves, and also the extent to which curve E is not an exact representation of the experimental results, are not of a magnitude which affects the present discussion.

[1] *Phys. Rev.*, Jan. 15, 1933.

Absorption Spectrum of the Vitamin E Fraction of Wheat-Germ Oil

So far as we are aware, the only attempt to investigate the absorption spectrum of vitamin E hitherto published is that of Evans and Burr[1], who reported that the vitamin E fraction of wheat-germ oil, while having high general absorption, did not give any definite bands that might help in following the concentration of the vitamin. We have now re-examined this point and have obtained results of a more promising character.

The absorption bands given by the untreated wheat-germ oil were so numerous and diffuse that it was difficult to disentangle them. At the temperature

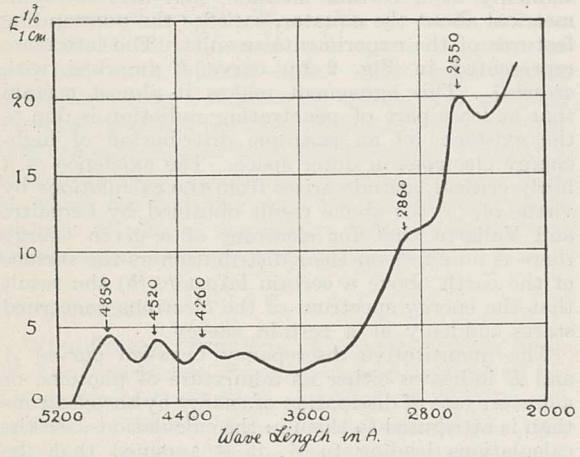

Fig. 1.

of liquid air, however, the broad diffuse bands became sharper and many of them showed detailed structure, so that the task of analysing and allotting them was rendered very much easier. A description of the bands shown by the non-vitamin fractions will be given elsewhere. The vitamin E fraction, obtained by the saponification of the oil by alcoholic potash at 37° C., followed by extraction with ether and the removal of sterols from the non-saponifiable residue by crystallisation and precipitation by digitonin, gave the curve shown in Fig. 1. The height of the peaks is given only approximately from photometered plates.

The spectrum includes three well-defined bands in the blue with maxima at 4850, 4520 and 4260 A. These bands, which were remarkably sharp even at ordinary temperatures, were detected in the original oil, but their strength was increased fifty-fold in the concentrate. In the ultra-violet (apart from a small band at 3370 A.) stronger absorption began at 3020 A. with a small step-out at 2860 A. and a well defined maximum at 2550 A., followed by general absorption from 2400 A. down.

The absorption bands were not affected by prolonged exposure of the concentrate to air or oxygen at room temperature, while the only effect of hydrogen peroxide was to increase slightly the absorption in the far ultra-violet at 2400 A. A stream of 10 per cent ozone, however, passed for a few seconds destroyed both the visible bands and the incipient absorption in the ultra-violet at 3020 A. and 2860 A. The band at 2550 A. was more resistant and was little changed. More prolonged ozonisation caused heavy continuous absorption in the ultra-violet.

The concentrate was not sensitive to light of wavelengths longer than 4000 A., but exposure to the full light of a mercury arc for a period of 45 minutes destroyed the bands in the visible spectrum as well as the incipient absorption at 3020 A. and 2860 A. The band at 2550 A. was, however, again but little changed.

Experiments on the selective destruction of the various bands by monochromatic irradiation, on the correlation of the strength of bands with biological activity, and on the absorption bands of concentrates of vitamin E from various sources are now in progress.

Philip Bowden.

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Cambridge.

T. Moore.

Nutritional Laboratory, Cambridge.
March 10.

[1] Evans and Burr, "Memoirs of the University of California", p. 144, 1927.

Polarisation of Echoes from the Kennelly-Heaviside Layer

The object of this letter is to correct an error made by me in a letter published in Nature of September 10, 1932, p. 398. The letter dealt with the subject of the polarisation of echoes reflected from the Kennelly-Heaviside layer. It was stated that according to the magneto ionic theory the left-hand circularly polarised ray should be more attenuated than the right-hand one. This is an error and the reverse is the case. I have to thank Prof. Appleton and Mr. Radcliffe for pointing this out in their letter to Nature of September 24, 1932, p. 472.

An accidental reversal of a $\pm$ sign on turning over a page was the cause of the trouble. There is now no disagreement on the theoretical side. As regards the experimental results I find, on looking up my records, that at any rate in one case, the polarisation of the single surviving F_1 echo after the split echo had disappeared was measured in the period immediately following the determination of the polarisation of the components of the split echo, so that the polarisation of the survivor was without doubt the same as the polarisation of the most bent ray in the split doublet, that is, right-handed. This condition persisted, on this occasion, for most of the afternoon.

Recent experience with an improved receiver has substantially confirmed our original observations as to the opposite polarisations of split rays, but indicates that it is impossible to generalise with regard to the strength of the various types of rays.

We have had periods on which the F_1 ray is predominantly right-handed and periods when F_1 is the opposite, and again periods when F_1 alternates between right-hand and left-hand with periods of plane polarisation in between. So far as a rather limited set of observations goes, during the daytime F_1' and F_1'', the right- and left-hand circularly polarised echoes respectively, appear on the average to be of the same order of strength. F_2 and F_3 are, however, predominantly left-handed although right-handed F_2 and F_3 have occasionally been observed. The wave-length used throughout these experiments was 60 m. and the base line between transmitter and receiver was 1·2 km.

It may be of interest to note that we have been able to get echoes from a neighbouring transmitter about 50 yards from the receiver which only radiated between 0·1 and 1 watt; the received intensities varied between a fraction of a microvolt/m. and about 20 μv./m.

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Acceleration of the Decomposition of Crystals of Barium Azide by the Emission from Radium Emanation

DEHYDRATED crystals of barium azide decompose at a measurable rate above 100° C. giving nitrogen as a gaseous product. There is an induction period very similar to that observed with mercury fulminate and the reaction spreads from centres of metallic barium formed on the surface and in the interior of the crystal (F. E. Harvey, unpublished). The induction period is shortened and the rate of centre formation increased if the crystals are exposed to the emission from a platinum seed containing radium emanation. At 110° C., the induction period is shortened from 120 min. to 55 min. and the rate of acceleration of the reaction trebled when the intensity of the emission from the emanation seed is about 1 m. curie.

The experiments so far carried out indicate that the acceleration of the reaction is due to an increased rate of nuclear formation. From the nuclei of metallic barium formed, the reaction spreads out at a rate which is about three times greater than for nuclei formed by thermal means.

W. E. GARNER.
C. H. MOON.

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Feb. 27.

Crystal Structure of Diphenyl Series

A COMPARISON of the results of crystal structure analyses of diphenyl, *p*-diphenylbenzene and *p*-diphenyldiphenyl gives evidence that in this series of compounds the benzene rings in each molecule are coplanar and linearly extended. The three substances crystallise in structures of $P\ 2_1/a$ symmetry with unit cells which are nearly identical in the *a* and *b* directions and have the respective lengths of 9·50, 13·59 and 17·72 A. along the *c* axis. From the marked similarity not only in dimensions but also in the intensity of those reflections which are less dependent on the length of the molecule, it is apparent that there is a similarity of structure and that in each case the length of the molecule is roughly parallel to the *c* axis.

The orientation of the benzene rings in the diphenyl crystal was determined by Krishnan from magnetic susceptibility measurements and confirmed by Dhar in an X-ray study. The molecule was found to be planar and its position in the unit cell was defined. The structure of *p*-diphenylbenzene has now been determined in this Laboratory and a Fourier analysis will shortly be published. The results show that the molecule is extended in a single plane at a tilt to the axes which, though not identical with that in the above case, does involve a similar alignment of the molecules with respect to each other. Preliminary results from the study of *p*-diphenyldiphenyl indicate that a corresponding arrangement exists in this case. I should very much like to hear of higher compounds of this series which would be available for study.

A comparison of the optical properties of these compounds is of interest. In all three substances the optic axes lie in the 010 plane and one optic axis is in the field when viewed along the perpendicular to the 001 face. In each case the ray vibrating in the direction most nearly parallel to the length of the molecule is the slow ray. The three compounds are optically positive and the degree of curvature of the isogyre shows that they become increasingly positive as the molecule lengthens. This is to be expected, since, with an increasing number of phenyl groups, the chain character of the molecule becomes relatively more important than its planar character, especially as the molecules are parallel as regards their length but have their planes mutually inclined at an angle of approximately 66°. It is proposed to carry on a more detailed study of the optical and magnetic properties of the series in this Laboratory.

LUCY W. PICKETT.

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March 10.

Strange Spatfall of the Common Mussel on the Common Cockle

AN interesting and unusual spatfall of the common mussel, *Mytilus edulis*, on the common cockle, *Cardium edule*, resulting in a related and dual mortality was observed in 1932 in the course of investigations on the extensive cockle beds of Cark sands at the head of Morecambe Bay. In June, heavy falls of mussel spat (5–10 mm. long) were found in several large areas on these beds, an event unprecedented in the experience of local middle-aged fishermen. At low water on these desert-like sands, the areas with mussels loomed in the distance like rocky outcrops. Such an unusual spatfall may be regarded as a natural experiment on the part of *Mytilus* to establish itself on sandy ground.

The spat had settled about and below half-tide mark actually on living cockles, which were so abundant in parts as to push one another to the surface of the sand. The fishermen were commonly taking 1 cwt. of cockles (mean length about 30 mm.) from about 10 square yards of ground at the lower levels (about 45 individuals per square foot). An important bionomic feature of these grounds is that, wherever examined, the sand was found to contain but little silt and to pass wholly through a sieve with 0·5 mm. circular holes. In November one of these areas was again visited and examined. It was found to be littered predominantly with clumps of dead cockles lying on the surface of the sand and held together by the byssus threads of recently existing

mussels. A few living and moribund cockles could be found here and there among the clumps. Gaping mussel shells ranging to about 31 mm. in length remained attached in many of the clumps, while groups of ten to thirty small, living mussels (to 23 mm.) could also be found occasionally among the collections of dead cockles. It would seem that the original clumps had been worked out of the ground by wave-action and that the cockles held fast by the byssus threads had been unable to burrow again.

In view of the doubtful compatibility of sand and mussels[1] this natural experiment is of much interest. The results at the end of the summer show clearly that most of the affected *Cardium* died, and that the loss of *Mytilus* was so great as to render the spatfall a failure.

The population of *Cardium* existing on the beds consisted mainly of individuals of medium size (and age), for the frosts in the early months of 1929 destroyed such large numbers—according to local fishermen—that economic collecting became difficult in 1930. The total yield of cockles from the Lancashire and Western Sea-Fisheries District in the years 1928–32 was 20,746, 10,892, 9,195, 14,846, and 17,117 cwt. respectively, while those for the important last quarter in the year were respectively 5,816, 1,969, 5,413, 6,607, 7,601 cwt.[2] At Cark it is noteworthy that the recovery in 1932—three years after the destructive frosts—was so complete that *Cardium* was considered to be unusually abundant. These facts are of interest in connexion with other observed effects of the unusually cold weather of 1929[3].

The cockles in the clumps would appear to have died from various subjective causes, and senility may be regarded as non-significant. As very little force is apparently required to prevent the valves of lamellibranch shells opening[4] (unsuspected factors may however add somewhat to the known force) it is probable that the entangling byssus threads of the mussels frequently effected more or less permanent occlusion of the shell-valves of *Cardium*, thus tending to starvation and difficulties in respiration. The unusual exposure of *Cardium* on the surface of the sand would subject the animals to wide and unusual variations in temperature, and might very well also involve difficulties in the operation of the feeding mechanism[5,6]—even in unimpeded feeding—over a labile substratum of loose fine sand.

The failure of the mussel spatfall was no doubt partly due to the attacks of predatory fishes, but since numerous empty valves occurred in the clumps, subjective death had occurred and probably from the same causes as operated on *Cardium*. Owing to the strong tidal currents over the beds, it is probable that the water surrounding the clumps would be rarely free from suspended sandy particles, and *Mytilus* may be expected to be less well adapted for dealing with such a situation than is *Cardium*, which possesses an internal *gill-shield* against which the ingoing current would tend to impinge[5].

From the facts of this natural experiment it may be concluded that (*a*) mussel spat was present in the spring in the water over a large area of the beds in a condition to settle on suitable places; (*b*) settlement was not effected on sand; (*c*) settlement was effected on cockles in certain places where these were abundant; (*d*) the latter spatfall was a virtual failure and resulted in killing the animals used for attachment. It is a reasonable deduction from the facts that mussel spat cannot effect a settlement on fine sand consisting of particles less than 0·5 mm. in diameter, but that given a larger firm surface a temporary lodgment may be attained.

J. H. Orton.

Zoology Department,
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March 21.

[1] R. W. Dodgson, Fishery Invest. II, **10**, 1, p. 160, 1928.
[2] J. T. Jenkins, Lancs. and Western Sea Fish. District, Quarterly Reports, Preston.
[3] J. H. Orton and H. M. Lewis, *J. Mar. Biol. Assoc.*, **17**, 2; 1931.
[4] J. Johnstone, L.M.B.C. Memoir II, p. 20, 1899.
[5] J. H. Orton, *J. Mar. Biol. Assoc.*, **9**, 3, 459; 1912.
C. M. Yonge, *ibid.*, **16**, 2, 331; 1926.

Control of Respiratory Movements in Crustacea

Whereas in mammals the factors controlling lung ventilation have been intensively studied, data for respiratory control in the invertebrates are relatively scarce. The cases hitherto investigated of the environmental factors (other than temperature) which influence respiratory movements in the invertebrates have shown that sometimes both carbon dioxide excess and oxygen deficiency act as stimulants (snails[1], *Octopus*[2], insects[3,4]), sometimes carbon dioxide alone is effective (*Squilla*[5]), while in other cases it is oxygen alone which is responsible (*Tubifex*[6]).

We have undertaken a comparative study of the controlling factors in members of a single group of invertebrates, the Crustacea, which live in a variety of different habitats. The results are briefly as follows. Neither carbon dioxide excess nor oxygen deficiency in the water accelerates the rate of respiratory movements in the barnacle *Balanus balanoides* (opercular valves) or in *Cheirocephalus diaphanus* (limbs). Oxygen deficiency, but not carbon dioxide excess, accelerates the scaphognathite beat of the crayfish *Astacus fluviatilis* and the pleopod movements of the fresh-water isopod *Asellus aquaticus*. Both an increase in the amount of dissolved carbon dioxide in the environment and a decrease in its oxygen content quicken the pleopod beat in the amphipods *Gammarus pulex* and *G. locusta*.

It is thus clear that not only in the invertebrates generally, but even within one group, the Crustacea, there is great diversity in the response of the respiratory appendages to oxygen lack and carbon dioxide accumulation. It is not known what is the ecological significance of such differences, nor do we yet understand their physiological causes. Are respiratory centres excited by blood stimuli or by nerve impulses from chemical receptors? The small size of most invertebrates has not permitted the question of blood stimuli to be studied directly; there is evidence, on the other hand, that at least in some forms chemical receptors are operative (*Tubifex*[6], cockroach[4]).

In the amphipods which we have studied it is unlikely that a nervous reflex is involved since there is a considerable latent period before the response appears. With these animals the effects of both oxygen deficiency and carbon dioxide excess are so closely similar that a common cause is suggested, which may be a fall in blood *p*H caused in the case of oxygen lack by incomplete oxidation of acid metabolites. It is clear, however, that oxygen deficiency cannot thus act through blood *p*H in all animals, for we found that while oxygen lack accelerates the respiratory rhythm in the crayfish and in isopods, carbon dioxide excess does not do so.

Respiratory control is more efficient in the fresh-water amphipod *Gammarus pulex* than in the marine species *G. locusta*, for in the former the accelerated pleopod beat is permanent at each increased carbon dioxide or diminished oxygen tension, while in the latter it is transitory. This greater efficiency may be necessary to *G. pulex* because its oxygen consumption is twice that of *G. locusta*[7].

H. MUNRO FOX.
M. L. JOHNSON.

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University of Birmingham.
Feb. 28.

[1] Dahr, *Lunds Univ. Arssk.*, **20**; 1924.
[2] Winterstein, *Z. vergl. Physiol.*, **2**; 1925.
[3] Stahn, *Zool. Jahrb.*, **46**; 1928.
[4] Hazelhoff, *Z. vergl. Physiol.*, **5**; 1927.
[5] Matula, *Pflügers Arch.*, **144**; 1912.
[6] Alsterberg, *Lunds Univ. Arssk.*, **20**; 1924.
[7] Fox and Simmonds, *J. Exp. Biol.*, **10**; 1933.

'Raw' Weather

IN NATURE of January 7, the question is raised why moist cold air should feel 'raw'. Sir Leonard Hill, in the same issue, gives an explanation very commonly accepted in physiological circles. May I direct attention to some comments on this topic made by me in the *Journal of Physiology*, vol. 57, 1923? "The uncomfortable feeling caused by cold moist air is attributed, so far as any explanation has been given, to the moist air being a better conductor of heat than dry air. This cannot, however, be the correct explanation, for the diathermic properties of all ordinary gases and mixtures of gases are very close to each other. The cause I take to be that in moist air there is a partial equilibration of the skin gel with the vapour pressure of water in the air leading to a swelling and to a diminution of the small air spaces. The swelling is, in fact, detectable with a strong lens or with a low power of the microscope. As a result of this diminished air enclosed between the epidermic scales the conducting power of the skin is increased".

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University of Melbourne.
Feb. 15.

Time Determination

I SUGGESTED a new method of observation for time determination in my letter in NATURE for October 29, 1932[1], and Mr. H. L. P. Jolly has made some interesting comments thereon[2]. My principal aim was to find a method which would be sensibly free from systematic error. Since my first communication, observations have been obtained in India with a first experimental equipment by three observers—Messrs. Mathur, Banerji and myself on seven nights each, before I came away from India on leave; and further observations on fourteen evenings have since been made by Mathur and Banerji.

With ten stars observed, the range of variation on any one evening never exceeded 0·3 sec. For precision the equipment needs to be improved before it can compete with the moving wire micrometer method, with which at Greenwich the variation between five time stars rarely reaches 0·1 sec. But as regards personality, I think the results are encouraging. They are

$$M. - B. = 0{\cdot}012 \pm 0{\cdot}010 \text{ sec.}$$
$$H. - \tfrac{1}{2}(M. + B.) = 0{\cdot}002 \pm 0{\cdot}012 \text{ sec.}$$

Personality appears to be quite as small as that found with the moving wire micrometer. Perhaps it is definitely smaller—but the observations are not yet sufficiently extensive to decide this. The method, then, promises well as regards observer's personality.

As regards systematic error due to mechanical causes, Mr. Jolly has pointed out advantages of this method owing to the reduction of mechanism, which he would like to eliminate entirely. As matters stand, the shutter is very small and its motion is minute. Its very motion may be incorporated in the wireless time signal receiving circuits and so compared directly with the rhythmic signals by the coincidence method. The shutter motion may be regarded as the clock indication of time; then only *variations* of lag of the shutter motion, occurring during star observations and time signal reception, are significant. I fancy that there should be little difficulty in keeping this variation down to a few thousandths of a second.

For geodetic purposes of determination of field longitudes, present-day requirements will be met amply if a probable error of 0·01 sec. is not exceeded, so long as systematic error also is no greater. For fixed observatories studying variation of longitude, these limits should be reduced tenfold, if results are to be on a footing with those of observations for variation of latitude.

Survey of India. J. DE GRAAFF HUNTER.

[1] NATURE, **130**, 666, Oct. 29, 1932.
[2] NATURE, **130**, 964, Dec. 24, 1932.

The Borrowed Days

IN the Calendar of Nature Topics in NATURE of March 25, page 445, there is a note about this legend. No reference is made, however, to the change from the Julian calendar to the Gregorian, whereof the effect at the present time has been to cause April 10–13 new style to correspond with March 29–31 old style.

The legend itself was no doubt in full currency long before the change of calendar; witness the following passage in "The Complaynt of Scotland", published in 1549.

"There eftir i entrit in ane grene forest, to contempill the tender yong frutes of grene treis, becaus the borial blastis of the thre borowing dais of Marche had chaissit fragrant flureise of evyrie fruit tree far athwart the fieldis."

Among Scottish country folk the legend still runs in rhyme, thus:

"March says to Averil,
'I see three hoggs on yonder hill.
If ye will lend me days three,
I'll find the way to mak them dee.'
The first day it was wind and weet;
The second day was snaw and sleet;
The third day it was sic a freeze
It frose the birds' nebs to the trees.
When thae three days was past and gane,
The silly hoggs came hirpling hame."

Hoggs in Scots are not swine, but two-year-old sheep.

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Research Items

Chastity in Bechuanaland. Changes in the attitude of the Southern Bantu to premarital chastity and pregnancy and their cause are discussed by Dr. I. Shapera in *Africa*, vol. 6, No. 1, in the light of investigations among the BaKxatla of the Sotho-Tswana cluster in Bechuanaland Protectorate. As among other tribes of the group, the essential element in marriage is the transfer of cattle from the family of the bridegroom to that of the bride, known under the name of *boxadi*. According to traditional practice, strict chastity used to be required of both sexes before they entered the initiation classes, and any boy who was known to have transgressed was liable to be killed while under instruction and in any event was regarded as having disgraced his family and tribe; while a girl who became pregnant had to submit to a variety of humiliations, as well as mockery from other girls, this last being the most serious deterrent of all. The child was either aborted or killed at birth. On completion of initiation, the girl was usually married at once, while the boys were drafted into regiments, and as they were permitted to marry only girls from an age-class junior to their own, marriage was postponed for some years, during which period they had access to the younger wives of other members of their family—usually of the father's younger brother. The changed attitude of the present day, characterised by looseness of morals and a much milder attitude towards the unmarried mother, is due to a variety of causes, among which are mentioned the abolition of the initiation classes at the instance of the Church, freer intercourse between the sexes before and after adolescence, the greater license of the youths awaiting admission to the regiments, the freedom in sexual matters acquired by the men while away in European employment and the preponderance in the number of women owing to the fact that many males do not return to the tribe when they once leave.

Census of Nigeria. The reports and detailed figures of the 1931 census of Nigeria have now been published in six volumes ("Census of Nigeria 1931." 1932–33. London: Crown Agents for the Colonies.) In spite of severe curtailments in field work on the score of economy, the census reveals much of interest in problems of race distribution and changes in Nigeria. In vol. I the results as a whole are discussed by Mr. S. M. Jacob. In the Northern Provinces, intensive counts were made in many villages throughout the area. For the rest, the figures were obtained by compilation from village lists, but on the whole are considered to have an error of not more than five per cent, and so low as one per cent in the intensive data. In the Southern Provinces, outside Lagos, there was no actual count and the figures are based on a computation derived from the number of taxable males. The margin of error is thought to be ten to twenty per cent. In Lagos, where a count was made, the error may be so high as ten per cent. The total figures for Nigeria, 19,928,000, show a seven per cent increase on those for 1921 but the 1921 figures cannot be regarded as accurate. Certain tribes appear to be increasing in number, Kanuri, Fulani, and Tuareg in the north, and Yoruba in the south, but Nupe in the north and several of the forest tribes of the Cameroons are infertile and tending to disappear. An extensive census of the southern provinces seems to be a desirable measure. A noteworthy feature is the remarkable drop in the death rate of Lagos for both native and European.

Census of Wapiti Deer in Wyoming. A co-operative count of wapiti, universally known as 'elk' in North America, was shared during the winter of 1931–32 by the U.S. Biological Survey, the Forest Service, and the Wyoming State Game Commission. Ground work was supplemented by use of an aeroplane, and the count is regarded as the most thorough yet made. It revealed the presence of 7,921 individuals on the four feeding grounds maintained by the Biological Survey, 679 on two State feeding grounds, and 11,255 spread out over the adjacent region, including national forest areas, and easily counted from the air because of a background of snow (Report of the Bureau of Biological Survey for year ended June 30, 1932). The total of 19,855 in the herd compares with 19,238 counted five years before, so that the herd appears to be maintained in almost stationary numbers.

Rodents of the Semipalatin District of Kazakstan. A paper on these rodents by B. A. Kuznetzov (*Bull. Soc. Nat. Moscou*, **41**, Nos. 1–2) results from an expedition to investigate the fur trade of this part of Siberia and to study the mammalian fauna of the area, the latter only being discussed here. The distribution of the species of wild animals is shown for the various districts, some of which have mountains under perpetual snow, while others are mostly steppe. The zonality of vegetation is not necessarily accompanied by one in the distribution of local species, high mountain and steppe forms of animals often being found together. The bulk of the work is devoted to interesting systematic and biological notes on the rodents of the area. The author asserts that some forms, such as the alpine hare (*Lepus timidus*, L.) and the squirrel (*Sciurus vulgaris*, L.) are decreasing in numbers through man's activity, while others such as *Cricetus Cricetus*, L. are increasing as a result of cultivation following forest clearing.

Antennal Secretion in Insecta. Although in a few exceptional cases the antennæ of adult insects are modified for special uses such as grasping the female, they have hitherto been regarded as entirely sensory in function. In this connexion a number of antennal receptor organs have been described which are believed to respond to various external stimuli and are accordingly said to be either tactile, olfactory or auditory (Johnston's organ). It is therefore of some interest to note the recent discovery by Mr. S. Maulik (*Proc. Zool. Soc. London*, pp. 943–956; 1932) of a new and complicated type of antennal organ which he considers to be secretory in function. The organ occurs in the enlarged eighth antennal segment of the males of certain chrysomelid beetles of the genus *Agetocera*. It consists of an internal chitinised tube which opens by a well-marked external orifice on to a specialised surface. Two types of organ have been distinguished, a long, tapering tube giving off into the surrounding tissue innumerable minute unbranched tubules of identical diameter, and a larger more or less dichotomously branched tube the ramifications of which

penetrate the surrounding tissue in tubules of continually decreasing diameter. The ninth segment is also modified in sympathy with the eighth but the connexion between them is unknown. The probable function of this organ is the dispersal of certain products of secretion in relation to some aspect of sex activity at present unknown.

Daffodils, Narcissi and their Hybrids. The classification of garden plants presents many difficulties which do not beset the systematy of wild flowers. The care and selection given by gardeners is responsible for new forms which become very numerous as years go by. Travellers also bring new species or varieties which add greatly to the confusion of classification whilst enriching the beauty of the garden. "A Monograph of *Narcissus*, subgenus *Ajax*", recently published by Mr. H. W. Pugsley (*J. Roy. Hort. Soc.*, **58**, pt. 1, 17–93, Feb. 1933) clears up many difficulties connected with the identity of several different types of daffodils. The history of the sub-genus *Ajax* is traced from the sixteenth century, when many varieties were already in cultivation. Two main sections of the sub-genus are now recognised—*Cyclaminopsis* and *Pseudo-narcissus*, and the latter is subdivided into six series :—*Minores*, *Lutei*, *Vulgares*, *Nobiles*, *Albiflori* and *Bicolores*. Twenty-seven species are described with such detail as to be useful to the botanist, the gardener, or the geneticist.

Inheritance of Grain Colour in Oats. Various investigators, beginning with Nilsson-Ehle, have found two factors present for black grain colour in oats. In crosses carried on at the Scottish Plant Breeding Station, Mr. William Robb (*J. Genetics*, vol. 26, No. 2) finds that the varieties Bell, Black Mogul, Black Tartarian and Sir Douglas Haig are homozygous for a single black factor, giving 3:1 ratios in crosses with white varieties. In the varieties Myrtle and Black Mesdag, however, two factors, *B* (black) and *G* (grey), are present, their formula being *B B G G*. *B* is epistatic to *G* and in crosses with white varieties an almost continuous series of grain colours is obtained, indicating a cumulative action of factors similar to that found in wheat. The variety Orion is found to be homozygous also for a third factor *B*, its colour formula being *B B B′ B′ G G*. The eleven white-grained varieties of oats tested were found to be homozygous recessives with the formula *b b b′ b′ g g*.

Cyclone Season in the South Indian Ocean. The cyclone season of 1929–30 is discussed by R. A. Watson and N. R. McCurdy in *Miscellaneous Publications of the Royal Alfred Observatory*, No. 12. This is the third publication in this series dealing specially with the cyclones of the western part of the South Indian Ocean, Nos. 7 and 10 covering the periods 1927–28 and 1928–29. The season under review appears to have been a remarkable one in many ways. In December the rainfall in Mauritius was nearly twice the previous highest, several places having the huge total of more than 60 in.—nearly three times the normal fall in London in a whole year. The synoptic weather charts showed numerous depressions which, although of considerable depth, were yet without the vigour of typical tropical cyclones ; even among those classified as genuine cyclones, none was notably intense. The storm of September 23–27, 1929, near Chagos Archipelago, was exceptional, first in that it originated less than 5° from the equator, and secondly, in its being only the second recorded in Mauritius so early as September during the past 119 years. The most intense cyclone gave a wind force of 10 on the Beaufort scale, corresponding with an average speed of about sixty miles an hour, at Reunion on February 2, 1930, and the lowest pressure recorded on the charts (994·6 millibars) occurred on the same day at Reunion. Such a wind speed is not uncommon in deep depressions in the neighbourhood of the British Isles ; the pressure scarcely merits the description 'low' ; and the event well illustrates the moderate and anomalous character of this cyclone season.

Momentum and Energy in the Special Theory of Relativity. In *Current Science* (1, No. 8, Feb. 1933) Prof. A. C. Banerji, of the University of Allahabad, considers some of the difficulties which arise when an attempt is made to combine the special theory of relativity with the ordinary ideas of momentum and energy. If the invariant masses of two particles are respectively m_1 at A and m_2 at B, and their relative velocity is v, an observer at A will estimate the total momentum of the two particles as $m_2 v (1 - v^2/c^2)^{-\frac{1}{2}}$, whereas the estimate of an observer at B will be $- m_1 v (1 - v^2/c^2)^{-\frac{1}{2}}$. Similar discrepancies arise in the estimate of the energy. The attempt to define the position of the centre of mass is subject to a similar difficulty, arising from the variation of the masses with their velocities, but also an additional difficulty arises from the ambiguity in the estimation of the relative distance.

Internal Conversion of γ-Rays. An account of the work of Mott, Taylor and Hulme on the internal conversion of γ-rays has recently appeared in these notes (NATURE, **131**, 99, Jan. 21, 1933). According to their results, the values of the conversion coefficient plotted against the frequency lie on one or other of two smooth curves according to whether the nuclear radiation is of dipole or quadripole type. The internal conversion data may thus be used for classifying nuclear transitions into two groups. In a paper by Ellis and Mott (*Proc. Roy. Soc.*, Feb.) the transitions of the thorium B and C bodies are studied from this point of view. According to a theory proposed by Gamow and largely verified by Ellis, the loss of an α-particle may leave the nucleus in an excited state which collapses, giving rise to a γ-ray. The number of γ-ray transitions from the excited levels is connected with the number of α-particles in the corresponding emission groups, which have been studied by Rosenblum. Knowing, then, the number of β-rays produced by internal conversion, the internal conversion coefficient may be estimated. The coefficients obtained mostly fit satisfactorily on the two curves. It is found that many of the transitions are of quadripole type and quantum numbers analogous to the azimuthal quantum number l are suggested for the levels.

Polarity of Hydrocarbon Vapours. McAlpine and Smyth (*J. Amer. Chem. Soc.*, Feb.) describe measurements of the dielectric constants of benzene, toluene, propane and propylene, all in the gaseous state. An important result is the absence of any change of polarisation with temperature in the cases of benzene and propane, which indicates that the increase previously observed with rising temperature in the case of liquids is due to decreasing intermolecular action. The zero moment found for the benzene

molecule agrees with its symmetrical structure, and the zero moment for propane is consistent with the absence of moment in the higher members of the series and shows that any polarity in the C–C bonds, electrical dissymmetry caused by repulsion in the molecule or difference in electronegative character between the hydrogens on the primary and secondary carbons, is too small to measure. The small moments found for toluene and propylene are of the same magnitude as those which might arise from inductive effects in the molecules.

Efficiency of Power Stations. In a paper on "Power Station Efficiency" read to the Institution of Electrical Engineers on March 23, Mr. W. S. Burge discussed the processes involved in the generation of electricity from coal and examined the effects produced by 'releasing' the heat at various temperatures. The main factors connected with the efficiency are four. The first shows how it varies with the steam pressure and the vacuum conditions. The second shows whether the maximum efficiencies of the various components forming the plant all occur at the same time or not, and the last two the effects of regenerative feed heating and superheating. The influence of the present physical limitations of the properties of metals, owing to the high temperatures used in practice, has also to be considered. The advances in the design of turbo-alternators in recent years have been so rapid that machines are now made which run at 3,000 revolutions per minute and have a capacity greater than 100,000 horse power. In the United States, it has been proved that when powdered coal is used, automatic control is more desirable than employing workmen. In one very large installation there, it is the habit of the 'watch' engineer to visit his boiler house only twice during an eight hour shift, although there is no one else in the boiler house. Mr. Burge considers that with no extension of steam conditions beyond about 650 lb. pressure per sq. in. and a temperature of 850° F., there is still wide scope for progress by making the plant item efficiencies have their values more nearly at the same time and thus improving the operating conditions. In his opinion, there is little scope for efficiency gain by using higher steam pressures and temperatures. Concentrated effort based on pressures of about 650 lb. pressure per square inch will produce the quickest and the best returns on the capital expended.

Astronomical Topics

Canals on Mars. An article by H. Boyd Brydon on this subject has recently appeared (*J. Roy. Ast. Soc. Canada*, Feb. 1933). It is in the main a discussion of E. M. Antoniadi's recent volume on Mars, and gives reasons for differing from his conclusion that all the narrow straight markings on the planet are an illusion.

The article quotes the following sentence from G. W. Ritchey describing certain observing sites (including Flagstaff): "The conditions of atmospheric definition and transparency are at least as much superior to those at Mt. Wilson as the latter are to the average conditions at the important observatories of northern Europe and the United States. The overwhelming impressiveness, the incredible tranquillity of the night sky seen at these very high semi-desert sites are beyond all description and imagination."

It is noted that the equivalent focus of the camera used at Flagstaff for Martian photography is 180 ft. Statements are quoted from Dr. Slipher that the photographs confirm the drawings as to the existence of a network of dark linear markings, sensibly uniform and continuous along their length; the photographs include a few double canals, but these are exceedingly difficult objects.

It is pointed out that M. Antoniadi lays undue stress on the fact that some drawings of the canals do not conform strictly to the laws of perspective.

Origin of the Solar System. A note in the Astronomical Topics in NATURE of November 5, 1932, gave some account of articles by A. C. Gifford on the above subject that appeared in *Scientia* last year. The note suggested that in giving the views of Sir James Jeans as to the age of the planetary system, thousands of millions of years should be substituted for the value millions of millions, stated in his articles. Mr. Gifford now quotes a passage from Sir James Jeans's earlier writings which certainly does suggest that he then assigned a more remote epoch for the stellar appulse than a few thousands of millions of years ago. Since that passage was written, much work has been done by cosmogonists in endeavouring to determine the age of the earth and the other planets. Their work is based on both astronomical and geological considerations, notably on a study of uranium and the products of its disintegration. The results are summarised by Dr. Harold Jeffreys in his book "The Earth"; the maximum estimate is about twelve thousand million years, the minimum one about a tenth of this. It is evident that Sir James Jeans now accepts these estimates; his article on Cosmogony in the "Encyclopædia Britannica", 14th edition (1929), vol. 6, p. 492, concludes as follows: "Our sun is a member of a colony of some thousands of millions of stars, the galactic stellar system. We do not know much about the number or arrangement of stars in the outlying parts of this system, but only in the dense central regions are stars at all likely to pass close enough to one another to produce planets. And here calculation shows that under present conditions planetary systems are only likely to be produced at the rate of about one in 6,000 million years. Thus our solar system with its age of only a few thousand million years is very possibly the youngest planetary system in the whole colony. Our terrestrial civilization, with only some 6,000 years of existence behind it, is almost certainly the youngest civilization."

Annuaire of the Observatory of the University of Belgrade for 1933. This *Annuaire* is a useful volume for all observatories engaged in meridian work. It gives apparent positions, at ten-day intervals throughout the year, of 240 fundamental stars for which ephemerides are not given in any other publication. There are also tables giving true sidereal time and the reduction from true to mean; the short period terms in the nutation are given for every day. There is also a list of new minor planets.

Population Problems in the Pacific*

SINCE the publication of Rivers's "Essays on the Depopulation of Melanesia" in 1922, much attention has been given to the population problem in the Pacific and the causes of the decrease in numbers of the natives. A discussion at the Sydney meeting of the Australian and New Zealand Association for the Advancement of Science afforded a welcome opportunity for taking stock of the advance that has been made in the interval towards a real understanding of the factors involved. So far as it is possible to draw any general conclusions from the observations which were reported in the discussion and the inferences drawn from them, it would appear that while the psychological factor, on which Rivers laid so much stress, is still regarded as of importance, there is a tendency to attach greater significance to food and the need for medical attention. On the other hand, it is evident that there has been some change—perhaps even in a considerable degree—in conditions since the time when Rivers's observations were made. Some of the populations appear to be approaching, or even to have attained, a state of equilibrium in their contact with Europeans. Where this is occurring, credit must undoubtedly be given to wise methods of administration.

The discussion was opened by Sir Hubert Murray, president of the Association, who was in the chair. In a communication on "Depopulation in Papua" he said that while there is no evidence of depopulation in general, there is a decline in the Eastern Division and the South-Eastern Division. The main causes he believes to be three—insufficient food-supply, disease and the passing of the old modes of life. His conclusion is that some tribes may succumb altogether, but the more resistant stocks will remain and their natural increase will be more than enough to make up the loss. He advocated the introduction of new foods rich in vitamins, and the extension of the activities of medical officers.

Mr. E. W. P. Chinnery, of the New Guinea administrative service, pointed out the necessity for a census and Mr. F. E. Williams, Government anthropologist of Papua, while arguing that the administrator must apply the conclusions reached by science, suggested certain lines of action which should be taken forthwith by the administration while scientific workers are continuing their investigations. The factors in the depopulation problem, he holds, fall into two classes, pre-European and post-European. The pre-European factors, native warfare, sorcery and certain sexual practices, act as checks and must be removed. Among post-European factors are introduced disease and the loss of interest in life, these being of major importance, while of minor importance are increasing masculinity and the decline of polygamy. He stressed the importance of the limitations of the food supply.

Prof. Raymond Firth in "Indices of a Stable Population" dealt with the population of Tikopia, where the factors of fertility are outstripping those of morbidity and the population is increasing. This is due chiefly to the fact that former checks are inoperative. Hence pressure is being put on the food supply, much to the consternation of the old men. This last aspect of the problem of population was also considered in a communication of a more general character from Prof. S. H. Roberts, who laid stress on the economic factor and advocated the intervention of the administration to secure economic regeneration. Dr. Ian Hogbin, dealing specifically with the causes of depopulation, examined the contention that the islands were becoming depopulated before the arrival of the European on the scene, and the actual evidence for an increase in the death-rate and its causes. Prof. J. Macdonald Holmes, taking into account the number of extra-territorial peoples, especially Indians and Chinese, now resident in the Pacific, also dwelt on the economic factor, and inquired whether trade relegated the native to an inferior position and broke down tribal or family organisation.

A valuable communication on "The Medical Sciences in Relation to Depopulation" by Dr. R. W. Cilento followed. He divided the effects of European intrusion on native races into three stages. In the first, attack by arms, by new diseases and by dislocation of tribal life caused an enormous decline. This stage has long passed in the Pacific. The second stage is one of partial adjustment, when the European seeks to impose his scale of values on the native. The native loses the safeguards of savagery and, as he fails to get a substitute, a state of disequilibrium follows. This is to be seen in many parts of Melanesia. Finally, either the factors for decline predominate and the native race disappears, or adjustment becomes gradually complete and the population begins steadily to increase. Of the causes of depopulation, by far the most important are disease and food deficiency. The psychological factor, Dr. Cilento believes, is not the cause of depopulation, but merely an effect. Mental lassitude and bodily weariness follow chronic disease and prevent anything but the most essential tillage of the soil, thus providing and accentuating a vicious circle by further impoverishing the diet. The attitude of hopelessness is not a primary condition resulting from the disruption of native custom. The best method of attacking the depopulation problem is by going to the root of the trouble, devoting more attention to medical services and improving native diet by providing foods rich in protein and vitamins A, C and E. The lack of fertility is correlated with the lack of vitamin E, in which native foods are especially poor.

Dr. W. M. Strong also dealt with this aspect of the problem in his communication on the "Nutritional Aspects of Depopulation and Disease". He stressed the importance of vitamins in the diet, especially of indentured labourers, and quoted cases in which beriberi and scurvy have been cured by changes of diet, while he thinks that even tuberculosis might be averted by the provision of good nourishing food. Influenza epidemics have always caused more deaths in Papua when they have followed a drought. He urged the cultivation of a greater variety of native crops.

Dr. T. Wi-Repa pointed out that since the last century, when it was feared the Maori would die out, the population has increased.

The work of the missions in relation to the question of depopulation both in the past and at the present time was discussed by the Rev. J. W. Burton and the Rev. J. S. Needham, who pointed out that the missions not only check harmful customs such as

* From the report of a discussion on "Population Problems", Australian and New Zealand Association for the Advancement of Science, Sydney Meeting, August, 1932. *Oceania*, 3, No. 1, 91–100.

infanticide, but also provide new interests, such as organised games, which take the place of warfare.

The discussion closed with an important paper by Dr. A. P. Elkin on "The Cultural and Racial Clash in Australia", which in its broader implications has a bearing on native problems in a wider field than that with which it deals immediately. He pointed out that the coming of civilisation brought about a sudden change in the environment of the aborigines of Australia. Before the advent of the white man, the aborigines had reached an almost static condition of equilibrium, which was maintained by an intricate, but logical, system of social, legal, religious and technical customs, ensuring the cohesion, solidarity and persistence of the aboriginal race in its environment. The change worked by the coming of the white man has been almost as hard, objective, and inhuman as a geographical change. Tribal and horde grounds, which were associated with the past through sacred sites and beliefs, are used by the white man for his own purposes. Being unable to perform the initiatory, historical and totemic rites in the way and at the sites sanctified by tradition, the aboriginal feels that there can be no future for him and prepares to die. Being unable to adapt himself to this new environment, he has rapidly decreased in numbers. The Australian race is another example of a type so specialised and adjusted to one environment that it cannot adapt itself to another.

Thomas Norton and the "Ordinall of Alchimy"

As one of the earliest alchemical books in English, the "Ordinall of Alchimy" is of much interest; Dr. M. Nierenstein and Mr. P. F. Chapman are therefore to be thanked for their exhaustive inquiry (*Isis*, 18, 290–321; 1932) into its authorship. Ashmole, in his "Theatrum Chemicum Britannicum", is the chief authority for ascribing the "Ordinall" to Thomas Norton of Bristol, who was supposed to have flourished in the fifteenth century. Ashmole's evidence for the authorship of this anonymous poem was that "from the *first word* of this *Proeme*, and the *Initiall letters* of the *six* following *Chapters* [namely, 'Tomais Norton of Briseto'] . . . we may collect the *Authors* Name and place of Residence". As for the date of the book, there is the statement at the end of the seventh chapter: "In this yeare of *Christ* One thousand foure Hundred seaventy and seaven, This Warke was begun, *Honour to God in Heaven*".

Dr. Nierenstein and Mr. Chapman, from a consideration of the language of the poem, and of the authorities quoted in it, regard the date 1477 as, in all probability, correct; and Dr. Peter Haworth, whom they consulted, says that the "Ordinall" certainly belongs to the second half of the fifteenth century. The problem of authorship is, however, more confused. Dr. Nierenstein and Mr. Chapman say that Norton's name, in connexion with the "Ordinall", became known only in 1617–18, when Michael Maier mentions him as a master of alchemy who wrote in English verse, and published a Latin version of the "Ordinall" in his "Tripus Aureus". They do not, however, notice that (according to Mrs. Singer's "Catalogue of Latin and Vernacular Alchemical Manuscripts", 2, 556–7; 1930) two fifteenth century manuscripts of the poem exist, in which the author is described as "T. N." This would appear to afford weighty support to Ashmole's 'cipher' theory; though it does not necessarily follow that "T. N." belonged to the well-known Bristol family of which he is usually described as a member.

Dr. Nierenstein and Mr. Chapman have very carefully and thoroughly sought out the records of the Bristol Nortons, and have constructed a genealogical table of the family, covering the relevant period, so far as is necessary to establish the interrelationship of those members named Thomas. There appeared to be four Thomas Nortons, and four only, for whom any case could be made out as possible authors of the "Ordinall". Thomas Norton I was alive in 1388, and may therefore be safely rejected. Thomas Norton II is equally ruled out, as his will was proved in 1449. As to Thomas Norton IV, he was certainly dead in 1479, and it is extremely unlikely that he was alive in 1477. There remains Thomas Norton III, who, as great-grandfather of the alchemist Samuel Norton (1548–1604 ?), would seem to have the best claim, since Samuel refers to his ancestor as an alchemist. However, Thomas III also is unacceptable to Dr. Nierenstein and Mr. Chapman, who state that he was a thoroughly disreputable character, according to the Bristol records, "avoiding divine service" and spending "sermon time in the afternoon at tennis and frivolous sports". His will was dated November 26, 1513, and the authors think that he must have died soon after.

The conclusion at which Dr. Nierenstein and Mr. Chapman arrive is that Maier and Ashmole were not justified in definitely ascribing the anonymously written "Ordinall" either to "Thomas Norton" or to "Thomas Norton of Bristol". While no fault can be found with this cautious statement, it yet seems probable that Maier and Ashmole were correct; and in view of the well-known character of many alchemists, it is perhaps surprising that Dr. Nierenstein and Mr. Chapman did not consider that Thomas Norton III—who, on chronological and other grounds, is obviously eligible—has a strong claim on the very grounds of his disreputability. E. J. Holmyard.

Prehistoric Society of East Anglia

At the annual business meeting of the Prehistoric Society of East Anglia held on February 18, Dr. Cyril Fox, director of the National Museum of Wales, was elected president for the year 1933, Prof. V. Gordon Childe, vice-president, and Mr. G. Maynard, of the Ipswich Museum, general secretary.

After the business meeting, specimens were exhibited and papers read. Mr. R. N. Chandler sent an account of his researches during the past six years in the basal gravel of the Swanscombe Terrace of the Thames Valley, where he had obtained more than 200 implements belonging to Stages 1 and 2 of the Clactonian culture. Fully 50 per cent of the artefacts are cores of which the chopping tool characteristic of

the industry may be considered a variety. One type of tortoise core now described for the first time appears peculiar to the Clactonian of Swanscombe, while another approximates to those characteristic of Crayford. Some of the cores are remarkable for their size and weight, two described weighing 16 lb. and 19 lb. respectively. Ten types of artefacts are distinguished and the series dealt with in the present paper, and in that published in 1929, illustrate all the types of Clactonian implements so far known at Swanscombe.

A communication from Miss N. F. Layard described the discovery in the Buttermarket, Ipswich, of bone implements beneath 9 ft. of soft gravel, and at a depth of 23 ft. from the surface. A bone needle with hour-glass perforation, a bone awl, the handle of some implement, and an antler tine perforated for suspension, were associated with a human tooth and fragment of jawbone. The objects were removed from the matrix by Miss Layard, personally, in 1899, and the circumstances carefully noted at the time. It was submitted that the needle corresponded with the broken-eyed needles found by M. Didon in the Abri Blanchard, Dordogne, in an Aurignacian deposit and other late palæolithic cave deposits in France, figured by Didon and by Lartet. Mr. J. Reid Moir stated that, if actually *in situ* in the deposit described, the specimens would be of Palæolithic age. Mr. M. C. Burkitt compared the finds with those made at the Wookey Hole, which were of Late Celtic age, and doubted their greater antiquity.

Lieut. K. R. U. Todd exhibited flint implements discovered in the alluvial beds bordering the south shore of the Orwell Estuary and submerged at high tide. One industry is characterised by long blades associated with burins ; one was 137 mm. in length, while a hundred measured specimens gave an average length of 67 mm. Dr. Godwin's analysis of the peat on which certain implements of early Neolithic forms rested indicated a temperate climate of post-glacial, Atlantic type, whereas the similar long blade industry found on the north shore of the estuary and described by Mr. J. Reid Moir, had been tentatively referred to the Madelenian by Prof. H. Breuil, and the measurements of the present specimens from the south bank were very near those from the type station of La Madeleine. Mr. M. C. Burkitt and Mr. Graham Clark compared the industry associated with the floor in the peat with that at Lower Halstow, and emphasised the occurrence of burins in Mesolithic times. It has to be remarked, however, that there is more than one cultural horizon in the Orwell alluvial beds, and that it is now regarded as highly probable that the long-blade industry comes from floors at lower levels than those yielding the flints for which Mesolithic associations were claimed in the discussion.

Experimental Gob Fires

THE Safety in Mines Research Board has issued papers Nos. 75 and 76, concerning gob fires, written by T. N. Mason and F. V. Tideswell (London : H.M. Stationery Office, 1933. 1*s*. net and 6*d*. net). The first of these deals with the possibility of explosions in sealed-off areas in non-gassy seams, and the second with the possibility of the revival of heating by in-leakage of air. The experiments were carried out in a special building arranged for the purpose at the Experimental Station at Buxton. This building consists of a central chamber 30 ft. square and 9 ft. high to simulate a mine goaf, circumscribed by an air-course approximately 6 ft. wide by 7 ft. high. The chamber and air-course are connected by doors 6 ft. square capable of being closed, and in one corner of the air-course there is a centrifugal blowing fan.

The first group of experiments simulated a fire in the goaf in a pack situated centrally in the goaf chamber ; with an open fire it was found that there was no possibility of the formation of an inflammable atmosphere ; with an enclosed fire this was found to be possible, though no inflammable atmospheres were actually produced under the conditions of the experiments. The next set of experiments simulated a gob fire developed in a roadside coal pack such as would be caused by a partly crushed pillar with a waste area behind. The most dangerous condition was when the fire was supplied with air from a leakage from intake to return, which also partly ventilated the waste.

A third set of experiments simulated fires in dirt packs adjoining a waste, the dirt containing as usual in practice approximately ten per cent of coal. Apparently no explosions occurred, but it is not safe to conclude that such conditions would never lead to the formation of an inflammable atmosphere. Special emphasis is laid on the fact that if an underground fire is to be sealed-off, the sooner and the more quickly that operation is carried out the better. The maximum danger of the formation of an explosive mixture is immediately after the sealing-off.

Paper No. 76 shows that an in-leakage of air which causes the oxygen content to rise to as little as 5 per cent (in one case 3 per cent only) usually results in a marked increase in activity of the heating. It was found that when the temperature had fallen so low as 75° C., a fire may be revived under suitable conditions. It is pointed out that although the flame of a safety lamp is extinguished when the oxygen in the air has fallen below 17 per cent, that is no guide whatever in determining whether an atmosphere is capable of extinguishing a gob fire or not.

Calendar of Nature Topics

Second Buchan Cold Spell

April 11–14.—Of the six 'cold spells' enumerated by Dr. A. Buchan, the second, April 11–14, receives the least support from either fact or folk-lore. There appears to be no popular saying associating these days with a fall of temperature, and the average daily temperatures at Greenwich from 1841 until 1930 do not reveal any marked cold period in April. An examination of the figures for the individual years at Kew Observatory from 1881 until 1923 showed that April 11–14 had been more often above the temperature to be expected at this season than below it. A different series of years might give a different result, but the inference is clear that Buchan's second cold spell has no real existence in London.

Spawning of Frogs, and a Remarkable Tadpole

The factors which determine the time of the spawning of frogs, the temperature of the air or the temperature of the water of the spawning pond or

what not, have not been determined (so far as we recollect), but the range in time of the incidence of spawning suggests that the main factors might be readily discovered. In Hampshire, Gilbert White's earliest record of frogs spawning was February 28, his latest March 22; in Sussex, William Marwick's corresponding dates were February 9 and April 10; and in Cambridgeshire, Leonard Blomefield found a shorter range, March 4 to March 25, the average of nine years' records being March 16.

These observations relate to the common frog (*Rana temporaria*) in England, but in India spawning takes place about the same time, and the discovery of the eggs of *Rana afghana* in the Khasi Hills towards the end of March 1930, enabled Dr. S. L. Hora to describe the development of the curious suctorial disc by which the tadpole adheres to rock surfaces in the rapid streams in which it lives (*Trans. Roy. Soc. Edinburgh*, 57, 469; 1932). The sucker is formed from the posterior lip of the tadpole, a lunate callous band on the under surface of the body, and lateral folds of skin which at first include the cement organs, although these disappear as the disc becomes functional. Dr. Hora thinks that the origin and development of the sucker can be explained by a series of small and gradual changes induced by recognisable factors in the environment, such as the speed of the current in which the tadpoles found themselves. The stages in the development of the disc are not necessarily correlated with the size of the specimens, as if the relative swiftness of the stream at different points provided the stimulus for the development of the disc.

Fish Cultivation in the Philippines

During April and extending to June or July occurs the spawning season of the most important of the sixteen hundred species of fishes recorded from the Philippines—the bañgos or milk-fish (*Chanos chanos*). It is by far the most common fish in the Manila market, and that because it is the product of a fish-pond industry in which a vast amount of capital, estimated at 45 million pesos, has been expended. Somewhat resembling a herring in shape and colour, though far exceeding it in size, this shiny silvery-white fish with pale steel-bluish back owes its value to a combination of qualities. It grows rapidly and may reach a length of three to four and a half feet; it is amongst the most prolific of fishes—a 30 in. female contained a little more than 3,000,000 eggs, a 44 in. specimen 5,700,000 eggs; it is wholly vegetarian and highly palatable; it is one of the few marine fishes adaptable to artificial cultivation in salt- and brackish-water ponds; and its fry is easily captured in enormous numbers (Adams, Montalban and Martin, *Philippine J. Sci.*, Jan. 1932, p. 1).

The first fish-ponds were tidal and were cut off from the sea except for an opening through which fry could enter but could not return to the sea. That uncertain method of stocking has been replaced in the more advanced fish-ponds by deliberate collection and transference of fry to specially designed ponds. A 10-hectare fish farm should accommodate 25,000–30,000 fry, at the rate of 50 fish to a square metre of pond; from these about 15,000–18,000 will reach the fingerling stage, which is transferred to growth ponds; and the final harvest may be reckoned at 9,000–11,000, or 900–1,100 per hectare. Although the bañgos reach quite a large size in the ponds, they never become mature, and breed only in the open sea.

Societies and Academies

London

Physical Society, Feb. 3. F. J. W. Whipple: Relations between the combination coefficients of atmospheric ions. The principal object of the paper is to put forward for consideration a formula, $\eta_{12} - \eta_{10} = 4\pi e w_1$, which indicates that the combination coefficient η_{12} for small ions and large ions of the opposite sign exceeds the coefficient η_{10} for small ions and uncharged nuclei, and further that the difference between the two coefficients depends on the mobility w_1 of the small ions. The experimental evidence for the formula is discussed as well as possible applications. G. P. Thomson, Norman Stuart and C. A. Murison: The crystalline state of thin spluttered films of platinum. Films of platinum spluttered in various gases have been examined by the method of electron diffraction. They often show patterns which indicate that the small crystals are oriented with one face parallel to the surface of the specimen, the crystals being otherwise at random and in many cases the crystals are very small, of the order 5×10^{-7} cm. Some films of platinum dioxide showed crystals of the order 2×10^{-7} cm. E. V. Appleton and R. Naismith: Weekly measurements of upper atmospheric ionisation. The ionisation is 2·2 times as intense on a summer noon as on a winter noon, and, in general, was slightly less in 1932 than in 1931. This reduction is due to the approach of sunspot minimum, and, with other evidence, suggests that the ionising agency from the sun varies by as much as 60 per cent during the 11-year solar period. Although ultra-violet light is accepted as the major ionising agency, thunderstorms most probably constitute one of the subsidiary causes, as previously suggested by C. T. R. Wilson. J. A. Ratcliffe and E. L. C. White: An automatic recording method for wireless investigations of the ionosphere. The Breit and Tuve method is employed, and both the transmitter and the time base at the receiver are synchronised with the A.C. mains. Some specimen records are reproduced and are used to illustrate the normal diurnal variation of equivalent height. Attention is directed to a common 'abnormal' occurrence of increase of ionisation in the lower (E) region, during the hours of darkness, without a corresponding increase in the upper (F) region, due possibly to storm clouds, as suggested by C. T. R. Wilson.

Edinburgh

Royal Society, March 6. J. B. Simpson: The late-glacial re-advance moraines of the Highland border west of the River Tay. Following upon the westward retreat of the last general ice-sheet from the central valley of Scotland and an incursion of the sea when the land level was at least 90 ft. lower than now, considerable re-advances of the ice occurred on at least two occasions. The first of these is described in detail for the district between Dunblane and Perth. From varved clays the period between the retreat and the re-advance is estimated at 640 years. This re-advance is correlated with the Ra moraines of Scandinavia. A later re-advance is marked by striking terminal moraines in the Upper Forth Valley and Loch Lomond areas. E. B. Bailey: Help from America in reading Scottish tectonics. It is now

often possible, by adopting American technique, to determine on mere inspection whether a particular rock is upside down or right way up. This possibility exists wherever a rock shows graded bedding, since in each individual bed with a contrasted coarse and fine margin, the coarse margin is the older. Also wherever current bedding involves an erosional contact, the eroded rock is the older. Many fruitful applications of these two principles during recent years in Scotland and Northern Ireland were outlined. Among other discoveries it has been revealed that thinning, in the Ballachulish district, has taken place preferentially in the normal limbs of large-scale recumbent folds. This opens a new department of tectonics, wherein drag is more important than thrust. T. KERR : The pituitary in *Lepidosiren* and its development. Development is peculiar in that the external rudiment (ectophysis) of the gland originates as in teleosts and amphibians in the form of a solid ingrowth, but unlike these, later develops a cavity. The cavity persists in the adult, dividing the anterior lobe from the intermediate and posterior lobes. The adult organ is unlike that of any other class ; its structure and histology are considered.

PARIS

Academy of Sciences, Feb. 20 (*C.R.*, 196, 523–580). C. MATIGNON and M. SÉON : The action of steam on heavy petroleum oils and on certain cyclic hydrocarbons. Zirconia was used throughout these experiments as catalyst. Details of the results obtained with metaxylene, cyclohexane, cyclohexene, gas oil and mazout are given. The object of the work was to find an economical means of preparing hydrogen. A. BIGOT : The deformations of the Cambrian grits containing shingle in the neighbourhood of Cherbourg. PAUL DELENS and JACQUES DEVISME : Certain differential forms and associated metrics. N. ARONSZAJN : The decompositions of uniform functions. E. KOGBETLIANTZ : Laguerre's series. L. SANTON : Some results obtained with a supersonic blower. Study of the methods of measuring the velocities of air currents higher than the velocity of sound. With the hot wire anemometer, as the air velocity increases, the power dissipated first increases, passes through a maximum, and then decreases. J. LERAY : The movement of a viscous liquid filling space. JEAN LOUIS DESTOUCHES : Superquantification and mechanics in abstract spaces. F. HOLWECK and P. LEJAY : Contribution to the compensation of the European gravimetric network. J. DELSARTE : The binary ds^2 and the problem of Einstein. PAUL LE ROLLAND and PIERRE SORIN : A new method of determining the moduli of elasticity. MLLE. M. QUINTIN : Study of the temperature coefficient of the chain : copper, copper sulphate ; mercurous sulphate, mercury. Data are given for a temperature range of 0°–46·5° C. J. E. GARSSEN : The magnetic susceptibility of some mixtures of substances of large electric moment. The magnetic susceptibility of acetone-nitrobenzene and acetone-paranitraniline mixtures is not a linear function of the concentration. Whilst a chemical combination is not impossible, it is pointed out that another explanation is possible. PIERRE AUGER and GABRIEL MONOD HERZEN : The emission of neutrons by aluminium under the action of the α-particles. Mme. Irène Curie and F. Joliot have recently shown the presence of neutrons in the radiation emitted by aluminium under the influence of the α-rays, the proof being based on the measurement of the relative absorption in lead and paraffin. These results have now been confirmed by Wilson's method. The emission of neutrons by aluminium is much rarer than that of beryllium under the same conditions, but the general characters are the same. H. MURAOUR and G. AUNIS : The laws of combustion of colloidal nitrocellulose powders. LIGOR BEY, REZAT BEY and GABRIEL VALENSI : The titimetric determination of the sugars. Systematic study of the effects of variations of the working conditions in the titration of sugars with ammoniacal copper solutions. A. TRAVERS and LU : The volumetric determination of lead. The lead is precipitated by sodium hypochlorite as the dioxide and the latter determined iodometrically. PIERRE LÉVY : The halogen indices of the aleurite oils known as China wood oils. L. ROYER : The difference which exists between a mica and a clay with respect to the possible orientation of crystals deposited on them. PAUL GAUBERT : The properties of crystals of phlorizoside (phlorizine). MLLE. M. COLANI : Artificial ridges of the valves of lamellibranchs (Northern Annam). It is concluded that twenty deposits of shells of *Placuna placenta* found in Annam have been caused by neolithic man. MME. VORMS : The anatomical characters resulting from the arrest of development in galls. S. MAHDIHASSAN : The different symbionts of the cochineal insects producing and not producing wax. PIERRE GAVAUDAN : A certain correlation between the reversibility of the phenomena of cytoplastic instability and the spontaneous disappearance of the vital colorations of the vacuome in *Ascoidea rubescens*. RAOUL LECOQ : The rôle of B avitaminosis and of the food equilibrium in the utilisation of lactose by the rat. RAOUL P. MAY : The modifications observed in the spinal cord in the case of grafting or ablation of a rudimentary posterior paw in the embryo of *Discoglossus pictus*. MAURICE LECAMP : The induction of limbs and region of regeneration in *Alytes obstetricans*. PAUL WINTREBERT : The existence, in the blastula of amphibians, of a centre of mitogenetic induction, regulating development. ETIENNE WOLFF : A new direct teratogenic method allowing the production of monsters by means of electrolytic lesions. L. LEMATTE and E. KAHANE : Silica in the organism and the siliceous particles of the blood. It is probable that a part, at least, of the silica in the blood is of respiratory origin and that it is composed of siliceous dust resisting attack. G. DELAMARE : The generators of the primary helix of the body of the polyspiral spirochætes.

SYDNEY

Royal Society of New South Wales, Nov. 2. ALMA G. CULEY : Notes on the mineralogy of the Narrabeen series of New South Wales. The percentage of heavy minerals in the Narrabeen sediments is generally low. Zircon, rutile, tourmaline and picotite are constant constituents, while magnetite and ilmenite are commonly present. Garnet, apatite, monazite, spinel and hypersthene are peculiar to the northern sediments. Galena occurs in sandstones from Mount Victoria. Authigenic minerals recognised are : anatase in perfect crystals, accompanied sometimes by brookite, leucoxene and some secondary rutile, idiomorphic barytes, chalcopyrites and pyrites. Spherulites of calcite and siderite are present in several specimens. A sandstone from Bulli Pass has perfect quartz crystals developed in capillary

cavities, and also imperfect quartz crystals resulting from the enlargement of quartz grains. A mineralogical relationship between the Narrabeen series and Kamilaroi system is suspected. F. P. Dwyer and D. P. Mellor: A note on the occurrence of β-cristobalite in Australian opals. Powder photographs have shown the existence of β (high) cristobalite in Australian opals of both the precious and common varieties. In only three cases, precious opal (*Tintenbar*), wood opal and altered diatomaceous earth, does the complete pattern of β-cristobalite appear. In all others a single broad band in the position of the most intense line of the β-cristobalite pattern appears. In these specimens the crystallites are extremely small. Scarcely any change in the diffraction pattern appears when the latter class of opal is heated at approximately 1,000° C. for several hours. When heated in the presence of potassium chloride, the crystals appear to grow, since after this treatment the broad band disappears and gives way to the sharp line pattern of β-cristobalite. M. B. Welch: Moisture content of wood. It is essential, in order to avoid gaping joints and cracks, that wood should be thoroughly seasoned before use, and the only true indication of this condition is obtained by determination of the moisture content of the wood. Wood is continually in a state of swelling and shrinkage due to absorption or loss of moisture from the atmosphere, but only within small limits. The result of a large number of tests indicates that for Sydney an average moisture content of 13·5–14 per cent denotes properly seasoned timber. V. A. Bailey: The quantitative theory of interaction between different species of animals. A mathematical theory of animal populations, arising out of the biological analysis of Dr. A. J. Nicholson, is described in outline. The fundamental equations of the theory are stated and certain of their consequences, biologically interesting, are mentioned. The variations of the animal densities near the steady state in a special non-continuous case are determined and shown to be represented by functions of the form $Ac^t \sin(\lambda t + B)$, where A and B are constants dependent on the initial densities, and c and λ are simple functions of the host-species' power of increase F, with $c > 1$

Forthcoming Events

Saturday, April 8

Gilbert White Fellowship, at 2.30—(Annual General Meeting in the Hall of the Art-Worker's Guild, 6, Queen Square, W.C.1).—At 3, Sir John Russell: "Modern Trends in Agricultural Science".

Monday, April 10

Royal Geographical Society, at 5.—Discussion on "The Use of the New Grid on Ordnance Survey Maps", to be opened by Brigadier H. L. Winterbotham.

Institution of Electrical Engineers, at 6 (Joint Meeting with the Institute of Transport).—C. J. Spencer: "Electric Trolley Omnibuses".

Wednesday, April 12

Society of Glass Technology, at 2—(in the Mappin Hall, The University, Sheffield).—Annual General Meeting.

Official Publications Received

Great Britain and Ireland

Annals of the Solar Physics Observatory, Cambridge. Vol. 3, Part 2: Microphotometry of the Solar Spectrum from 4040 to 4390A. By Dr. R. V. D. R. Woolley. Pp. v+79–118. (Cambridge: At the University Press.) 7*s*. 6*d*. net.

Report of the Marlborough College Natural History Society for the Year ending Christmas, 1932. (No. 81.) Pp. 72+7 plates. (Marlborough.) To Members, 3*s*.; to Non-Members, 5*s*.

Researches published from the Wards and Laboratories of the London Hospital during 1932. 29 papers. (London: H. K. Lewis and Co., Ltd.) 7*s*. 6*d*. net.

City and County of Bristol: Bristol Museum and Art Gallery. Report of the Museum and Art Gallery Committee for the Period October 1st, 1931, to December 31st, 1932. Pp. 28+4 plates. (Bristol.) 2*d*.

Proceedings of the Edinburgh Mathematical Society. Series 2, Vol. 3, Part 3, February. Edited by Prof. H. W. Turnbull and Dr. E. T. Copson. Pp. 151–230. (London: G. Bell and Son, Ltd.)

National Joint Industrial Council for the Flour Milling Industry. Technical Education Series, Pamphlet No. 9: The Wheats of Commerce. 1: General Considerations. By Dr. E. A. Fisher and Dr. C. R. Jones. Pp. 51. 6*d*. net. Technical Education Series, Pamphlet No. 10: The Wheats of Commerce. 2: Commercial Wheat Classes. By Dr. E. A. Fisher and Dr. C. R. Jones. Pp. iii+53–104. 6*d*. net. (London.)

Biological Reviews and Biological Proceedings of the Cambridge Philosophical Society. Edited by H. Munro Fox. Vol. 8, No. 2, April. Pp. 107–240. (London: Cambridge University Press.) 12*s*. 6*d*. net.

Other Countries

Proceedings of the Imperial Academy. Vol. 9, No. 1, January. Pp. ii+30. (Tokyo.)

Japanese Journal of Physics. Transactions and Abstracts. Vol. 8, No. 2, February 10. Pp. iv+57–108+21–52. (Tokyo: National Research Council of Japan.)

Journal of Science of the Hiroshima University. Series A (Mathematics, Physics, Chemistry), Vol. 3, No. 1, December. Pp. 136. (Tokyo: Maruzen Co., Ltd.)

The Tôhoku Mathematical Journal. Vol. 36, Part 2, January. Pp. ii+189–397. (Sendai: Tôhoku Imperial University.)

University Observatory, Oslo. Publication No. 5: On the Theory of the Chromosphere and the Corona. By Svein Rosseland. Pp. 37. (Oslo: A. W. Broggers Boktrykkeri A.-S.)

Publications of the Observatory of the University of Michigan. Vol. 5, No. 4: The Elements and Ephemeris of Comet Dodwell-Forbes (1932n.) By Allan D. Maxwell. Pp. 39–42. (Ann Arbor, Mich.).

State of Connecticut. Public Document No. 24: Fifty-fifth Report of the Connecticut Agricultural Experiment Station, New Haven, for the Year 1931. Pp. xii+850+74. (New Haven, Conn.).

Geological Survey of Uganda. Memoir No. 3: The Volcanic Area of Bufumbira. Part 1: The Geology of the Volcanic Area of Bufumbira, South-West Uganda; with Notes on the Petrology and Economic Geology. By A. D. Combe and W. C. Simmons. Pp. xi+150+12 plates. (Entebbe: Government Printer.) 15*s*.

Forest Bulletin No. 80: List of Trees and Shrubs for the Kashmir and Jammu Forest Circles, Jammu and Kashmir State. By W. J. Lambert. Pp. v+40. (Calcutta: Government of India Central Publication Branch.) 12 annas; 1*s*. 3*d*.

The Science Reports of the Tôhoku Imperial University, Sendai, Japan. Fourth Series (Biology), Vol. 8, No. 1, February. Pp. 74+4 plates. (Tokyo and Sendai: Maruzen Co., Ltd.)

Meddelelser om Grønland udgivne af Kommissionen for Videnskabelige Undersøgelser i Grønland. Band 79, Nr. 4: The Godthaab Expedition 1928—Alcyonaria, Antipatharia and Madreporaria. By P. L. Kramp. Pp. 20. (København: C. A. Reitzels Forlag.) 1.00 kr.

Report of the Aeronautical Research Institute, Tôkyô Imperial University. No. 92: On the Transmissibility of Visible Light through a Cloud of Particles. By Daizo Nukiyama and Atsusi Kobayasi. Pp. 307–338. 35 sen. No. 93: Hôbutumen no Onkyôgakutekino Seisitu ni tuite (On the Acoustical Properties of Parabolic Reflectors), Part 2. By Kôzi Satô and Masaaki Sasao. Pp. 339–356. 25 sen. Tôkyô: Koseikai Publishing House.)

Scientific Papers of the Institute of Physical and Chemical Research. No. 409: Vitamin C in Japanese Green Tea. By Masataro Miura and Michiyo Tsujimura. Pp. 129–144. 20 sen. No. 410: On the Antiscorbutic Factor in Commercially Sterilized Milk and Japanese Green Tea—An Experiment upon Monkey. By Masataro Miura and Nagayo Okabe. Pp. 145–161. 25 sen. Nos. 411–413: On the Minor Constituents of Thermoluminescent Calcite, by Shin Hata; The Absorption Spectra of Naturally Coloured Fluorites, by Jun Yoshimura; Reactivation of the Blood Forming Action of Liver by Constituents of Gastric Mucosa, by Fumito Inukai and Waro Nakahara. Pp. 163–188. 40 sen. (Tokyo: Iwanami Shoten).

Canada: Department of Mines: Mines Branch. Anhydrite in Canada: Occurrence, Properties and Utilization. By L. Heber Cole and R. A. Rogers. (No. 732.) Pp. v+89+5 plates. (Ottawa: F. A. Acland.) 20 cents.

Catalogues

Microscopical Preparations: Zoological and Botanical Material. (Catalogue A, eighth edition.) Pp. 112. (Manchester: Flatters and Garnett, Ltd.)

Colorimetry and Nephelometry. (Section E33.) Pp. 15. Moll Thermopiles and Vacuum Thermocouples. (Thermo 33.) Pp. 4. (Delft: P. J. Kipp and Zonen.)

Books on Various Subjects in New Condition at much Reduced Prices. (No. 465.) Pp. 24. Catalogue of a Portion of the Library of the late G. Lowes Dickinson. (No. 466.) Pp. 24. (Cambridge: Bowes and Bowes.)