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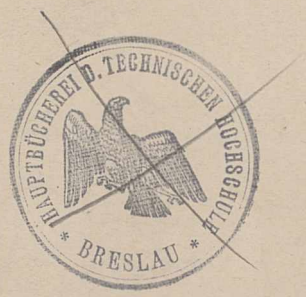
"*To the solid ground*
Of Nature trusts the mind which builds for aye."—WORDSWORTH.



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Of Nature trusts the mind which builds for aye."—WORDSWORTH.

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Scientific Worthies.

XLII.—HENDRIK ANTOON LORENTZ.

THE outstanding leader in physical science who is the subject of this notice was born at Arnheim in Holland on July 18, 1853, graduated at Leyden in 1875, became Professor of Mathematical Physics at that University as early as 1878, discharged the duties of that Chair with great brilliancy until his appointment a few years ago to the direction for research in the historical Teyler Institute at Haarlem, leaving Ehrenfest as his successor. He retains his connexion with Leyden as Honorary Professor, and does not treat that position as a sinecure: the weekly lecture delivered by him, and usually reported for publication by members of his audience, is one of the outstanding events in the University life. At Haarlem he leads the philosophic life, enjoying the society of his grandchildren, controlling the physical side of the Institute, which is also famous on the artistic side for the collection of the great local painter Franz Hals. The jubilee of his doctorate on December 11, 1900, was commemorated by the presentation of a volume of researches contributed by most of the notable cultivators of physical science in the world.

Since the middle ages the Low Countries have always been a seat of fervent and productive intellectual activity. In early times they were conspicuous for a broadening of the Catholic theological learning in the direction of humanism. Later, in the congenial soil provided by the achievement of ordered political liberty, they became a focus of Protestant learning, which under the stimulus of free controversy broadened out into the domains of Jurisprudence and Polity. Holland was the peaceful refuge of students such as Descartes and Spinoza: its free press played a principal part in the spread of learning in Europe, and was even

the means of original publication of some of the writings of Galileo. In physical science Huygens was one of an illustrious international company which included his contemporary Newton, and ranks next among his peers both in dynamics and in optics. In our own days the eminence of Holland in physical science is maintained by H. A. Lorentz, H. Kamerlingh Onnes, P. Zeeman, and others of a brilliant band who have been, in the main, products of the great University of Leyden which dates from the times of national revival.

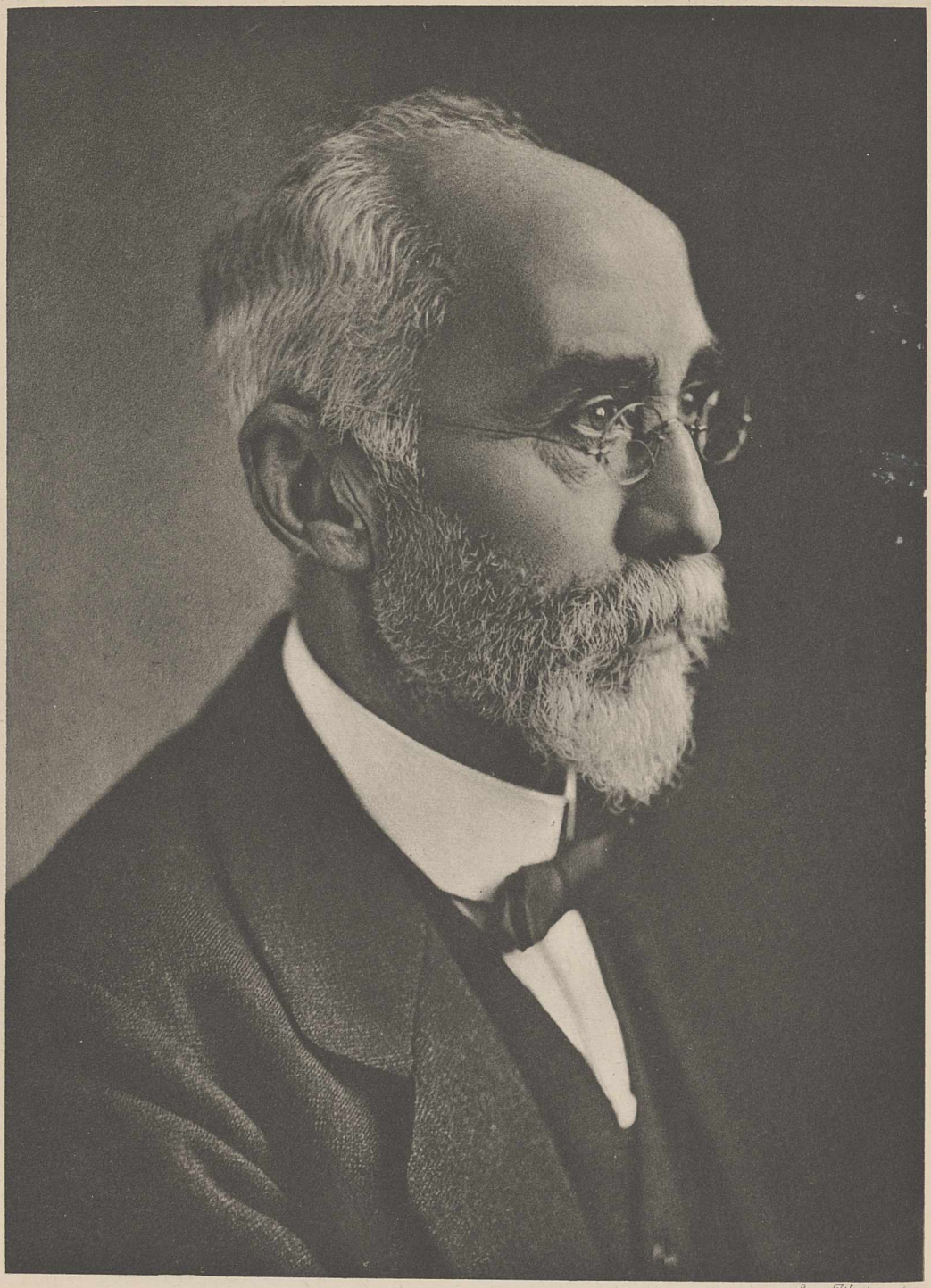
In his early days contemporaries in this country to whom Dutch sources were not very accessible owed their knowledge of Prof. Lorentz's writings mainly to expositions and discussions by a kindred spirit the late Lord Rayleigh, and subsequently by Lodge in connexion with his thorough experimental scrutiny of the relation of the Earth's motion to the aether, regarded as the seat of propagation of the rays of light by which we explore the universe. No trace could be anywhere found of exception to the principle that Lorentz favoured as the basis of optical theory, that the aether is a stationary medium: material bodies must thus be structures of molecular texture so open that, in the simile of Thomas Young when he pleaded in 1800 for a revival of the wave theory of Huygens, the aether penetrates through moving matter as freely as the wind through a grove of trees. The republication of some of Prof. Lorentz's early investigations, in which historical exposition and criticism are so happily blended with new advance, in vol. i. of his "Abhandlungen über theoretische Physik" in 1907 revealed, at any rate to one student, how much research into sources might have been saved him by earlier access to the *Archives néerlandaises* of 1887.[1] The volume also presented much unpublished material. There is for example a treatise on the Second Law of Thermodynamics and its relation to Molecular Theory, pp. 202-298. Nothing could be more valuable, for students who desire a real grasp of this fascinating subject, than connected exposition by a master, on general lines freed from excursions into detail.

This work was doubtless even fresher then than now, when the principles the scope of which is so universal have been sifted and refined in all directions in so many essays and text-books. The power and simplicity of the foundations of pure thermodynamics have at all times been a magnet to the most powerful minds, from Kelvin who persisted with the prescience of genius in hunting out and rediscovering in Paris the master tract of Sadi Carnot, down through Clausius, Maxwell, Helmholtz, Willard Gibbs. One can recall the crucial fundamental concept of Available, in contrast with Dissipated, Energy, introduced in a fragmentary way by Kelvin, whose wealth of fresh thoughts and of practical interests scarcely ever allowed him a chance of systematically developing any subject; its relation to the more convenient analytical concept of Entropy introduced by Clausius, and its physical elucidation in terms of a science of molecular statistics by Boltzmann and Gibbs; the luminous expositions and developments of Rayleigh; the theoretical outlook of Gibbs, vast enough to predict a full-blown new science of Physical Chemistry before it had come to birth; even such questions of pure logic as the intimate essential connexion of the principle of Carnot with the identification of heat as energy which came finally twenty years later. One remembers a remark of Prof. Lorentz in relation to an obituary exposition of Kelvin's early activity, that he had not been aware that this side of the subject had been so fully grasped at that early date.

In this historical feeling which has led Prof. Lorentz so frequently to interweave his own contributions to knowledge into a reasoned analysis of the actual position of the science at the time, close affinity may be traced with the work of Lord Rayleigh. For both of them, perhaps especially for the latter, an essential interest of human learning is the story of its historical evolution: nothing is so attractive as to recognise, still more to discover, the early insight of genius into problems usually thought to belong to later times. To both of them it appears to have been at least as congenial to explore and improve a wide field of knowledge, as to engage in strenuous special calculations such as are the very essence of progress in dynamical astronomy: though neither of them shirked such tasks when they presented themselves. Perhaps nowadays appreciation of the past is more than ever necessary to balance the haste of the present.

Of late years Prof. Lorentz's activity has been much turned by public demands into the direction of formal courses of lectures at University centres, in which his own thoughts and ideas are happily embedded. Thus the standard treatise on the Theory of Electrons arose out of lectures at Columbia University, New York, in 1905; several courses have been published in German; and a most interesting and concise reasoned account of the state of knowledge and speculation regarding statistical thermodynamic theories, leading up through Brownian movements and local fluctuations of energy into the mysteries of quanta, delivered at the Collège de France in 1912, came to be issued in French from Leipzig with additional notes in the year 1916. Earlier discussions on this latter subject (Abhandlungen, vol. i.) followed the lines developed also

[1] "Influence du mouvement de la terre sur les phénomènes lumineux": Abhandlungen, i. pp. 341-394.



Emery Walker, ph. sc

H. A. Lorentz

by Maxwell, Boltzmann, Rayleigh, Gibbs, which originated this domain of knowledge and, though now beset with fundamental experimental difficulties, are still the ultimate foundation of our ideas. The articles "Maxwells Electromagnetische Theorie" (June 1903) and "Elektronentheorie" (December 1903) in the Mathematical Encyclopædia are standard treatises.

His doctor's dissertation (1875) was a treatise (177 pp.) on the reflection and refraction of light, which was abstracted at considerable length by E. Wiedemann in his *Beiblätter*, vol. i., 1887. Proceeding from Helmholtz's form of the Maxwell theory, it develops a hint contained in a footnote in Helmholtz's first memoir, that the interfacial conditions of the electric theory are precisely those that lead naturally to Fresnel's standard laws of reflection. Transmission in metals also comes under review, and the laws of reflection from their surfaces; following up Maxwell's remark that gold leaf is far more transparent for the rapid electric alternations in light than its steady electric resistance would lead one to expect. It is curious that Maxwell himself has nowhere indicated the application of his theory to the dynamically fundamental subject of reflection. In a letter of 1864 to Stokes [2] in which he hints at his electric theory, then taking form, he remarks: "I am trying to understand the conditions at a surface for reflection and refraction, but they may not be the same for the period of vibration of light and for experiments made at leisure."

Other early papers published in Dutch, and reported in the *Beiblätter* by long abstracts, include a discussion of the propagation of sound according to the kinetic theory of gases (1880), and a note (1882), stimulated by a discussion of Korteweg, on formulæ for the interaction between two electrodynamic elements constructed after the manner of that of Ampère.

The famous memoir in which he applied for the first time considerations relating to discrete molecules to electric propagation in material bodies, and incidentally arrived at a rational refraction-equivalent $(\mu^2-1)/(\mu^2+2)\rho$ for each substance, independent of its density, is abstracted by himself in *Annalen der Physik*, ix., 1880, pp. 641-684. Here again the version of Maxwell's theory developed in the first of Helmholtz's critical memoirs (1870) is followed, possibly as being more accessible outside England. Indeed the expression for the refraction-equivalent is largely independent of any particular theory of propagation in the molecular medium; as is illustrated by the fact that his formula was identical with a result deduced ten years earlier in Danish on lines of elastic solid theory by his namesake L. Lorenz. The discussion of its range verified the rough substantial invariance of this expression even for change from the gaseous to the liquid state, and showed that it provides an additional atomic constant persisting through many types of chemical bonding of the atoms. This is now of course a large domain in physical chemistry.

The contribution of a vibrating molecule to the radiation is treated, after the manner of the general Stokes-Kirchhoff equations, in close correspondence as it happens with the familiar later formulation of Hertz for a dipole vibrator emitting electric radiation. Extension to include optical dispersion is considered. The result, already known to the masters, is enforced that Cauchy's statical theory which ascribed dispersion to a sensible value of the ratio of molecular distance to wave-length, is for actual matter entirely insufficient, unless as he remarks the laws of attraction are quite changed at molecular distances: but its effect is not absolutely null, and it is pointed out that cubic crystals, which are isotropic on Maxwell's theory, should on this account exhibit a small secondary double refraction of very symmetric type. Recently Prof. Lorentz has returned to this topic, and announced the detection of this quality, amidst others due perhaps to imperfection of the crystal, in his laboratory at the Teyler Institute. The detailed investigations of Rayleigh (1892) on atomic obstacles arranged in lattices stop short of the approximation here required. Later both Lorentz and Rayleigh noted that a perfect crystal should not scatter at all the light passing through it.

A static theory being thus inadequate, dispersion has to be ascribed to resonant vibration excited in the molecular structures. He works out as an example the very simplest ideal case, that of an electric charge e attracted to a massive nucleus by elastic force proportional to distance; which is the identical illustration that served him nearly twenty years later to elucidate the Zeeman magnetic spectral effect and the polarisation of the emitted radiation. The result of course also provides an illustration of the anomalous or selective refraction discovered by Kundt, which he does not then notice, restrained possibly by our ignorance which he remarks of the actual structure of molecules. Nowadays the argument for the Lorentz refraction-equivalent is made almost intuitive by correlating it with the equivalent $(K-1)/(K+2)\rho$ for the dielectric inductance K, usually ascribed to Mosotti and to Clausius. No demonstration could however be simpler than the one given even earlier by Maxwell in 1873 for the cognate problem of the conductance of a medium filled with small spheres of different material: "Elec. and Mag." i., § 314.

In 1884 Prof. Lorentz directed his attention to the

[2] "Scientific Correspondence of Sir George Stokes," vol. ii. p. 26.

effect which magnetisation exerts on the polarisation of reflected light, discovered by Kerr in 1878, and discussed immediately after on the basis of general theory by FitzGerald but only for transparent media. A magneto-optic constant had to be introduced for each metal, naturally of complex type, which might be regarded as continuous with the constant of the Hall effect for a steady field. Experimental research, based on his formulæ, was started in the laboratory of Prof. Kamerlingh Onnes by Sissingh in 1886, in collaboration from 1889 with Zeeman: and their results are finally reported in *Archives néerlandaises*, 1894. Everything connected with magneto-optics excited great interest in England from the time of Faraday's fundamental discovery, and the stimulating dynamical speculations of Kelvin (and Maxwell, "Elec. and Mag." ii.) connecting it with a rotatory molecular theory of magnetism. The discovery of Kerr intensified the interest. The very exact material provided by Sissingh and by Zeeman was available as a test for a concentrated theoretical formulation. One may be permitted to claim that the most systematic theoretical development and thorough verification of the subject, remarkably consistent on all sides, is in a Cambridge Fellowship dissertation by J. G. Leathem, Phil. Trans., 1897, pp. 89-127, which has scarcely received the attention that it deserves. This theory attains even to features of exact prediction, which had been anticipated in a dissertation in Dutch by C. H. Wind shortly before.

About 1897 came the cardinal discovery of the effect of a magnetic field on spectra, by Zeeman, which was worked out in the early stages in the light of Lorentz's theoretical guidance. As already remarked, the elementary illustration by a single vibrating ion under elastic control, which covers all the normal features of the Zeeman subdivision, had been used to illustrate optical dispersion long before. The results admit of easy extension to any system of electrons describing interacting free orbits, however complex, about a massive positive nucleus. When there are more than three components in a spectral line, the vibrating system must be more complex. The application of the theory of the small vibrations of general dynamical systems, which suggests itself at once, gave no help and it was scarcely to be expected that it would. Recent schematic solutions employing the language of quasi-periodic systems are said to cover thoroughly the whole ground: it would be most interesting to have Prof. Lorentz's reasoned views on the promise held out by this rather inscrutable type of analysis. One observes that he uses here as elsewhere the well-tried method of discussion by mirror images, to fix the types of symmetry (cf. *Astrophys. J.* 1899): the magnetic field is reversed in the image in order to avoid change of signs of all the charges, which would lead to negative nuclei and positive electrons.

There is a paper of 1892 in *Ann. der Physik* on refraction across thin metal prisms, in which one discovers a discussion of an essential point often sought for, namely, the influence on the direction of propagation by rays of the steep gradient of amplitude along the phase-front of the emergent train. The introduction to this paper is on lines now strangely familiar; an investigation of what type of differential equations one is formally restricted to by the principle of invariance alone, in order to give rise to simple trains of damped undulations in an isotropic absorbing medium.

We come now to the two famous memoirs "La Théorie électromagnétique de Maxwell et son application aux corps mouvants," *Archives néerlandaises* 1892 (pp. 189) and "Versuch einer Theorie der elektrischen und optischen Erscheinungen in bewegten Körpern," 1895 (pp. 139), both published as separate treatises. Both of them proved to be very difficult, in comparison with previous memoirs on cognate matters, partly on account of the strangeness and complexity of the notation and analytical processes to English readers saturated with Maxwell's notation and his more intuitive procedure. One might perhaps guess that both of them were worked up gradually, as seems to have been Prof. Lorentz's custom, out of professorial lectures: for they include digests of previous papers. The main feature in both is the expansion of the Maxwell theory on the basis of mobile elementary ions, regarded simply as coherent volume distributions of electricity, as the sources of the field. That point of view had already been clearly expressed in the paper of 1878-80 on refraction-equivalents and incidentally on the explanation of dispersion, but was then developed more in terms of attractions at a distance after Helmholtz. As regards the dynamical side, both memoirs proceed through the principle of d'Alembert in a form which makes it to some extent a substitute for minimal Action. Looking through them in the light of to-day the second, which appeared early in 1895 and referred largely to optical phenomena, seems much the more striking. Thus he recognises that the Maxwell stress for free space does not balance when the state of the system is not steady, unless a quantity which Poincaré afterwards described as a distribution of a momentum connected with the stress is taken into account: this was the beginning of the stress-energy-momentum tensor. The correction in the Fresnel convection-coefficient for transparent media is obtained, arising from dispersion, which in recent years Zeeman has fully verified. All kinds of optical convective phenomena are closely considered.

But the main result is the establishment of a systematic correspondence between the electrodynamic fields of a material system at rest in the aether and the same system convected with a uniform velocity v. The result in its simple form holds only up to the first order of v/c. The fields are not identical, unless certain of the vectors are ignored as being unreal and merely mathematical expressions. But he points out that all relations concerned with the interactions of matter, such as alone experiment could test, are unchanged by the convection. This is the first systematic appearance of the electrodynamic principle of relativity. It can be extended in modified form with confidence to the second order of v/c, at any rate on an electric theory of matter, for the electrons within the atom are still small enough compared to their distances apart to be treated as point charges; and that covers the whole practical field except the domain of β rays. But when, as Prof. Lorentz noted in 1904, the truth of the result as thus extended is found to hold for the field up to all orders, the completion of this exact correspondence to include the atomic structure has to become a postulate or assumption: that was the birth of the modern efforts towards unrestricted convective relativity as an abstract formulation holding far beyond experimental verification.

There is a striking formal analysis near the end for the effect of convection on rotational optical media. For an isotropic medium the ordinary rotational modulus will be altered, and also a new rotational effect involving interaction of the vector velocity of convection with the vectors of the field can arise. As the result is of the first order in v/c, it is difficult to see how it could exist on a purely electric theory of atomic structure; so that the two formal effects should cancel. It appears that the experiments of Mascart (1872) were scarcely adequate to verify this absence of effect. Anyhow the principle of electrodynamic relativity repudiates any effect altogether.

Hitherto the transformation, up to the second order, for convection was ascribed to the molecular system, the frame of reference of space and time remaining invariable. For steady states of the system, in which time does not come into consideration, it meant a shrinkage along the direction of convection: changes so rapid that the alteration of the measure of time could be effective scarcely occurred, and were put aside. When Prof. Lorentz pointed out that the transformation, which is now known by his name, was exact as regards electrodynamic fields in free space, and also exact to some extent when there are electric densities in the field, the subject took on a new and wider trend. The transformation was transferred by Einstein (in recent years attached to Leyden as part-time Professor) to the frame of space and time instead of the molecular aggregations of matter, each taken separately, which accidentally occupied it. The question is then no longer confined to shrinkage of the material frames of terrestrial experiments: effects must be expected over astronomical distances across empty space. Adaptation of the Newtonian law of gravitation into a form invariant for the fourfold space-time frame of Minkowski, which was the final analytical consolidation of this aspect of the subject, was effected by Lorentz and by others with a view to search for astronomical indications, and in particular to find out whether the outstanding minute secular rotation of the orbit of the planet Mercury, already the standard test for modified laws of gravitation, became amenable. The changes thereby introduced proved to be of small account.

Meantime Einstein seems to have been struggling to get rid of the Minkowskian uniform universal space-time, which was just as absolute in its combined four dimensions as was the Newtonian scheme of separate space and time. By identifying locally the essential features of a physical field with intrinsic differential constructs in the fourfold expanse, named tensors, of which a formal calculus had already been fully developed by Ricci and Levi-Civita, he was able finally to select a group of related local tensors as the result of tentative adaptations so as to exhibit the now famous view of gravitation as represented by warping of the fourfold pseudo-spatial expanse around the material nuclei. Though this can scarcely be said to have explained gravitation, it has been widely held to have explained (or abolished) space and time: it merely forced gravitation, just as it happens to exist, into the electrodynamic frame with its property of insensibility to uniform convection, with no detriment to the results of Newtonian physical astronomy and a rather better account of the problem of the Mercury perihelion.

This empirical building up of a field of gravitation out of tensorial constructs belonging to a space-time expanse, now differentially heterogeneous, was completed by adapting the Minkowskian vector potential of the pervading electrodynamic and optical field to the same conditions. The need for a more physical setting, at any rate to those who believe in minimal Action as the ultimate and necessary binding principle in physical analysis of a molecular world, seems to have been met immediately to a considerable extent by Lorentz and soon after by Einstein himself and by Hilbert. "The discussion of some parts of Einstein's theory of gravitation may perhaps gain in simplicity and clearness, if we base it on a principle similar to that of Hamilton. . . . Now that we are in possession

of Einstein's theory we can easily find how this variation principle must be formulated for systems of different nature and also for the gravitation field itself" (Proc. Amsterdam Acad., Jan. 30, 1915). This is not the place to pursue the contentious view (cf. *Phil. Mag.*, Jan. 1923) that the Least-Action dress, just because it is so closely interwoven, is like the shirt of Nessus, and tends to make havoc of the spatial philosophy though without destroying the tentative validity of the elegant analytical method. Possibly Prof. Lorentz may be tempted to unravel this question in his admirable judicial manner.

In the subsequent years the Proceedings of the Amsterdam Academy became a focus for the literature of the gravitation theory, mainly in a series of papers, apparently first delivered as lectures, by Prof. Lorentz himself, in which he develops the tensor scheme in an elegant way of his own by a differential geometry involving use of infinitesimal loci of constant geodesic radius as a kind of indicatrix. Among many other papers, doubtless arising from a common inspiration, one recalls Droste's determination, simultaneous with Schwarzschild's solution, of the exact gravitational field of a particle, and Nordström's of the field of an electron.

One can look back, still with undiminished surprise, at the vast mass of intricate literature on this subject which flowed westward, mainly from Berlin and Leyden and Göttingen (and also from Italy), when Central Europe was again thrown open after the end of 1918. The difficulties of a strange though potent and elegant calculus could be surmounted by application; but the mysteries of unfamiliar meanings and implications in imaginary space and time could give rise to abundant misconceptions. The uninitiated must still be wary in approaching this unexplored and treacherous domain, in which Prof. Eddington has recently detected for us, by beautiful analysis of algebraic tensors, how mere co-ordinates are liable to undulate across the field on their own account entangled with the gravitational waves in the underlying spatial reality.

There is no space to pursue this review of Prof. Lorentz's work further. A survey of his activity is a liberal education in the history of physical science for the last half-century. Reference to the Proceedings of the Amsterdam Academy for the last twenty years, in the handsome form of the edition in English, will reveal the breadth and informative character of his investigations. But this series of volumes is long and portly; and he would confer a great boon on students of physical science the world over if he could manage to continue the edition of Collected Papers of which the first volume appeared in 1907. He will be excused the task of reconstruction to bring them up-to-date which he then essayed, and which perhaps has been a cause of the delay.

Needless to say, Prof. Lorentz has attained to all the distinctions all over the world that are appropriate for a man of science. He has long been a Foreign Member of the Royal Society, and is in the lists of Rumford and Copley medallists. For the working congresses on the theories of physical science that are a feature of our time, he is an almost indispensable chairman. Great linguistic gifts, abounding learning, clear and rapid grasp of a point of view and prompt exposition of it in a different language, ease of approach, tolerant appreciation and encouragement of speculations still unverified, are familiar to his scientific colleagues. We may hope that his time will not be diverted overmuch to administrative work such as could be done by others. JOSEPH LARMOR.

The Botanical Survey of British Malaya.

The Flora of the Malay Peninsula. By H. N. Ridley. Vol. 1: *Polypetalæ*. Pp. xxxv+918. (London: L. Reeve and Co., Ltd., 1922.) 63*s*. net.

THE Malay Peninsula, for which the opening volume of a Flora by Mr. H. N. Ridley has been published "under the authority of the Government of the Straits Settlements," is an important and, save for the narrow northern section nearest Siam, a typical province of the Tropical Rain-Forest Region. Though Europeans secured a footing in this Peninsula four centuries ago, the survey of its vegetation was long deferred. The Portuguese, who occupied Malacca in 1511, had done little before their expulsion by the Dutch in 1641. The Dutch, who, with two short breaks (1795–1801 and 1807–18), owned Malacca till 1825, scarcely did more. Rumpf, whose "Herbarium Amboinense" (1750), completed on September 20, 1690, surveys the vegetation of the Malay Archipelago, avoided dealing with Malacca. Rumpf regarded the Malay Peninsula as belonging to continental India, and Valentijn, in his "Oost-Indien" (1726), held the same view.

The British became interested in the Peninsula when Penang was acquired in 1786. Sir Joseph Banks, president of the Royal Society, satisfied the directors of the East India Company that a survey of the vegetable resources of their territories was essential, and in 1793 the Calcutta Botanic Garden was permitted to add survey operations to its acclimatisation work. The investigation of the vegetation of the Peninsula, then begun in Penang, was extended to Malacca when that Settlement was first captured from the Dutch in 1795, and to Singapore when that Settlement was

founded at the second restoration of Malacca to Holland in 1818. Before Malacca became permanently British in 1825, Banks had died and the company had adopted another policy. Botanical survey at Calcutta was inhibited, and during 1828–32 the company dispersed the contents of the Calcutta Herbarium.

The valuable work accomplished by the Calcutta Garden since 1793 in Penang and Singapore, however, could not be undone; as regards Malacca, the reproach to England induced by this retrograde policy was removed by the private exertions of Griffith during 1841–44 and Maingay during 1862–69, whose collections went to Kew. Largely owing to Griffith's work, more than one-sixth of the plants described by Hooker and Thomson in their "Flora Indica" (1855) are Straits Settlements species; thanks to Maingay, the Straits Settlements plants in the two opening volumes of Hooker's "Flora of British India" (1872–79) rose to nearly one-fourth of the whole. During 1874–79, the Straits Government organised relationships with the western Native States which rendered the latter accessible. To assist Hooker the Calcutta Garden undertook, during 1881–86, the botanical investigation of Pêrak, and the Malay Peninsula plants described in those parts of Hooker's Flora issued during 1887–97 rose to nearly one-third of the whole.

In 1888 Mr. Ridley was appointed Director of Gardens and Forests, Straits Settlements; in 1889 King, at the desire of Kew and of the Straits Government, began at Calcutta his "Materials for a Flora of the Malayan Peninsula," as a supplement to the Indian Flora Hooker had already issued and a precursor of the Malay Flora Mr. Ridley has now commenced. By 1902 King had completed the Polypetalæ; the Materials of 1889–1902 thus correspond with the 1872–79 parts of Hooker's Indian work and with the first (1922) volume of Ridley's Malay flora. Two-fifths of the plants in King's Materials had not been reported from the Peninsula when Hooker's work was written; one-third were new species. Nearly one-fourth of the plants now described by Mr. Ridley had not been reported from the Peninsula when King wrote; one-seventh are species discovered since the Materials appeared. The vegetation of the Peninsula in wealth and variety claims comparison with the richest province of the Tropical Rain-Forest Region.

If much has been done to remove what was long a reproach to Europe, much, as Mr. Ridley explains in his introduction, has still to be accomplished before the vegetation of the Malay Peninsula can be regarded as fully investigated. A generation hence the additions to his Flora may be as extensive as his additions to King's Materials. This only increases our obligation to him for placing at the disposal of economic students the ripe and exact knowledge of which he has such a store, and gives rise to the hope that he may soon complete the task so worthily begun. His descriptions are clear and concise, and he has done well to confine his citations of earlier authorities within rigid limits; if there be a fault, it lies in the fact that occasionally he has exceeded his own limits by omitting references to the works he usually cites. By adding text-figures illustrating most of the families discussed, he has enhanced the value of the work; Mr. Hutchinson's drawings are so effective that the only regret they cause is that they should be so few. Those who use the work will not confine their commendation to the author and his artist; if the price be considerable, it will at least be conceded that printer and publisher alike have fulfilled their duties well.

Geodetic Levelling.

Ordnance Survey: The Second Geodetic Levelling of England and Wales, 1912–1921. Published, by Order of the Ministry of Agriculture and Fisheries, by Col. Sir Charles Close, Director-General of the Ordnance Survey, Southampton, 1921. Pp. 62+46 plates. (London: H.M. Stationery Office, 1922.) 17*s.* 6*d.* net.

THE accuracy of modern levelling is a thing which always causes surprise when the great number of separate operations which enter into the composition of a line of any length is considered.

In the work under notice perhaps the most striking result is that the line of levelling starting from mean sea level at Newlyn, not far from Land's End, and terminating at Dunbar on the coast of Haddingtonshire, generates in all that distance of about 600 miles a probable error of only two inches, so that, when it was found that mean sea level at Dunbar was ten inches above that at Newlyn, it was possible to say with confidence that the discrepancy was real and due to a deformation of the mean sea-level surface and could not be attributed to an accumulation of error in the levelling.

The volume contains an introduction by Colonel Sir Charles Close, four chapters by Lt.-Col. A. J. Wolff, and five by Mr. H. L. P. Jolly. The operations which it describes fall into two separate parts, namely, the determination of the mean sea level and the levelling.

Though the old levelling of England had mean sea level at Liverpool as its datum, the height of mean sea level had not been determined with accuracy, and a new determination was necessary; it was very desirable also to obtain records whereby the fluctuations of mean sea level could be examined and analysed. Accordingly, three tidal observatories with automatic

gauges were established, at Newlyn, Felixstowe, and Dunbar respectively. In the selection of these places the late Sir George Darwin was consulted.

The levelling shows that the equipotential surface through the mean level of the sea at Newlyn passes well below mean sea level at Dunbar and slightly above that at Felixstowe. There is thus a question as to what should be adopted as the datum for the levelling. Either the mean of the different sea levels might have been used or the equipotential through mean sea level at one point might be the datum for all. The latter was decided on and the decision was unquestionably right.

An interesting chapter is devoted to the effect of meteorological conditions on the level of the sea. This shows that part of the discrepancy of 0·81 ft. between mean sea level at Newlyn and Dunbar can safely be attributed to the fact that, for the six years during which the observations continued, the average barometric pressure was higher at Newlyn than at Dunbar by 0·108 in.; this would depress the level of the sea at Newlyn by about 0·12 ft. The greater portion of the difference still remains to be accounted for, however, and it seems that the cause may best be sought in the effect of wind.

The relation between the daily mean level of the sea at Newlyn and the atmospheric pressure-gradient has been studied and a formula deduced that gives results in wonderfully good accordance with observation.

That the levelling was carried out with conspicuous care and success is demonstrated by the smallness of the probable error of the long line from Newlyn to Dunbar; and the heights of the bench-marks are now known with such accuracy that if in the future these are found to have changed it will undoubtedly indicate that the marks have moved. The old levelling of 1850 was unfortunately not precise enough to permit of the differences found, considerable though they were, being attributed to real movement.

Particular attention has been paid to the design and to the selection of the situations of the bench-marks, on the stability of which the value of the work depends. The sites have been chosen with special regard to the geological conditions, "avoiding as far as possible the softer rocks and those liable to surface changes."

In the design of the primary bench-marks an interesting detail is that two reference marks, situated side by side, are provided in each; one is a piece of gun-metal and the other a polished flint. The number of primary bench-marks is large, the interval between them being on the average about thirty-five miles, and it is scarcely possible that any upheaval or subsidence of a geodetic kind can take place without affecting the heights of some of them.

The discussion in Chapter IV. of the dynamic and orthometric connexions is clear and good, but it should perhaps have been stated, with reference to the formula for the value of gravity, that though in all probability the results obtained by the use of Helmert's constants are sufficiently accurate, yet the correct quantity to employ is not the computed value of gravity but the actual value obtained by observation. We may feel tolerably sure, from experience gained in other countries, that the difference between these two values will not be great, but as no gravity survey of this country has ever been made we cannot say that we *know* that that is the case.

The errors to which levelling is liable are fully discussed in Chapter VIII. The origin of the systematic errors, which are undoubtedly met with, is obscure. It is here stated that "the systematic error must be systematic with respect to something and there is always the possibility of finding out what the determining condition or thing is. It is a matter of almost universal experience that the direction of levelling is one such condition." Until, however, some satisfactory explanation has been given of the way in which the direction affects the errors it cannot be said that the connexion has been definitely established.

The French levellers, under the direction of M. Ch. Lallemand, have probably paid more attention to this question than any one else, and it is worth noticing that the early procedure was to do the levelling in both directions on the same day, whereas now the rule is to do the second levelling on a different day. If the systematic error were principally due to the direction the best procedure would clearly be to do the two levellings on the same day, under as similar conditions as possible, when the effects of direction on the two results could be expected to be equal but opposite. It seems that this was the original expectation; experience, however, showed that the expectation was not fulfilled, and so the preference was given to separate dates, "qui assure" (to quote M. Lallemand) "une plus grande variété dans les conditions atmosphériques d'exécution des deux nivellements et, par suite, en cas de concordance de ceux-ci, autorise davantage à penser qu'ils sont exempts d'erreurs systématiques."

This evidence, however, is not very conclusive. Concordance may merely indicate that the errors were equal and of the same sign in both cases, so that whatever error there was will appear undiminished in the mean. Discordance means that most probably the errors were of opposite sign, but, the conditions under which the two levellings were done having been different, it would be unjustifiable to assume that the errors were equal. In neither case, therefore, have we any certainty that the mean of the two results will be free from error.

We agree with the statement made in Chapter VIII. "that there is reason to doubt whether the systematic error in the mean levelling of a line, derived from the discrepancy between the backward and forward levelling, is a reliable guide to the actual accumulation of error within the line."

Putting aside such matters as instability of pickets, which are clearly capable of producing a systematic effect depending on the direction in which the work proceeds, the connexion between the remainder of the systematic error and the direction does not seem to be well established and is a matter which calls for further investigation.

Turning to the equipment which was used for the levelling, special attention is due to the staves called the "Cambridge Staves," which came into general use in 1914. They are described by Lt.-Col. Wolff in Chapter II. The novelty of their construction is that the graduations are not on the wood of which the body of the staff is composed, but on a strip of invar let into a groove on the face of the staff. This strip is firmly attached to the base of the staff, and is presumably kept taut by some arrangement fixed at the top, but this detail of the construction is not given.

The thermal expansion of invar is so small that no account has to be taken of changes of temperature, which simplifies the computations and adds to the precision of the work. Staves of this pattern would be still more advantageous in countries where the climate is less temperate than it is in England.

The book is well illustrated, and the closing errors, discrepancies, adjustments, and route-profiles of the circuits are very clearly displayed in a series of diagrams. The work is well produced on the whole, but there are signs that the printers were not quite accustomed to mathematical symbols with accents, subscripts, etc. These are minor blemishes, however, and do not detract from the great value of this admirable piece of work. G. P. L. C.

Scientific Work in the Dutch East Indian Seas.

De Zeeën van Nederlandsch Oost-Indië. Uitgegeven door het Koninklijk Nederlandsch Aardrijkskundig Genootschap. Pp. ix + 507. (Leyden: E. J. Brill, 1922.) 20 guilders net.

THIS heavy volume, illustrated with numerous photographs and several folding maps, treating of our knowledge of the Dutch East Indian seas, is published by the "Koninklijk Nederlandsch Aardrijkskundig Genootschap" on the occasion of its fiftieth anniversary. In it, six specialists give a summary of the work done in their respective branches of science, and the results are worthy of the attention of many more than those acquainted with the Dutch language.

In the first chapter, Col. l'Honoré Naber gives a historical sketch of the research work that has been done, beginning with the famous Marco Polo, the first European who travelled in those seas in the thirteenth century, and whose book was translated into English by H. Yule (London, Cordier, 1903). More important for us, however, are the expeditions of the last century, when the *Challenger* began the work which was carried on by the *Siboga* and the *Bali*.

The second chapter, bringing forward Adm. Tydeman's work on the depths of the sea, is accompanied by a splendid map, showing the extension of the flats, as well as the distribution of the curious deep channels or troughs, that form one of the most characteristic features of this part of the world; for example, the Java trough, 6000-7000 metres deep, the Mentawei trough, and the well-known Mindanao trough, where the greatest depth of the sea, between nine and ten thousand metres, is found.

Then follow accounts of investigations on temperature, salinity, density, and dissolved gases in the sea water, communicated by Prof. Ringer. Many diagrams and tables are a welcome guide in what might have been a labyrinth of ciphers.

An account of the maritime meteorology and the tides, written by Dr. van der Stok, and illustrated by maps and tables, explains the interesting phenomena which tide-waves show in an archipelago, the isles of which form numerous obstacles to the movements of the water. The theoretical part of this chapter is highly interesting.

Dr. Max Weber's treatise on the biology of the sea is very important, as might be expected from the leader of the *Siboga* expedition. The different zones of life in the oceans, the coral reefs, and the conditions of deep-sea life are especially treated, and Mrs. Weber-Bosse adds an important chapter on plant life in tropical seas, which is so absolutely different from our coastal vegetation, where only very few Phanerogamæ come down to and into the salt or even brackish water of bays and estuaries.

The next chapter, on the geology of the region, by Prof. Molengraaff, is perhaps the most interesting of the volume. The writer first points out the remarkable difference between the western and eastern parts of the Archipelago. The western part, the shallow Soenda sea, was dry land during the Glacial period, while in the eastern part rows of little islands alternate with deep-sea basins, causing a very unequal relief of the sea bottom. The theory of the sinking of the sea-level and the coral-reef problem, which are narrowly

interlaced, are amply discussed. Good maps help to make these difficult problems easier to understand.

In the last chapter Adm. Phaff gives a description of the coast lines of the East Indian Isles.

In his preface Dr. W. v. d. Stok states that only new and very costly expeditions will be able to bring new light on the subjects treated in this volume, so we must therefore be glad to possess such an excellent summary of our knowledge of the East Indian Seas.

W. G. N. VAN DER SLEEN.

For the Diffusion of Knowledge.

Annual Report of the Board of Regents of the Smithsonian Institution, showing the Operations, Expenditures, and Condition of the Institution for the Year ending June 30, 1920. (Washington: Government Printing Office, 1922.)

OF the 704 pages that make up the volume before us, 550, accompanied by 230 plates, are assigned to the appendix. The body of the report is somewhat dead by now, but the large tail is still lively enough to attract attention. It consists, as usual, of papers general in character and ranging over the field of human intellect from astronomy to fine art. There are 27 such papers, of which 14 are original and by Americans, and 13 are reprints or translations of articles by American, British, and French authors. All are examples of popularisation of a high type, and many of them could be understood by readers with little or no previous knowledge of the subject. The names of H. H. Turner, W. D. Halliburton, M. Caullery, and Auguste Lameere among the foreign authors indicate the general excellence. The papers that appear here for the first time are, to a large extent, summaries of work that has been published elsewhere, but some of them contain matter that seems to be fresh.

Dr. N. E. McIndoo's article on the senses of insects may serve for example. After discussing the nature of insect vision by the simple and the compound eyes, he proceeds to the sense of smell, and considers it first as a means of recognition. In insects that sense is far more developed than in man, yet Dr. McIndoo found that by smell alone he could distinguish the three castes of bees as well as other components of the hive. It is probable that each individual bee has its peculiar odour, but the combination of all these that makes up the hive odour is regarded as the most important, as indeed the ruling power in a colony. It "is a means of preserving the social life of the bees from without, and the queen odour which is a part of it insures continuation of the social life within. The workers 'know' their hive-mates by the odour they carry. This insures harmony and a united defence against attack. The queen odour constantly informs the workers that their queen is present. Even though she does not rule, her presence means everything to the bees in perpetuating the colony. Thus, by obeying the stimuli of the hive odour and queen odour, and being guided by instinct, a colony of bees perhaps could not want a better ruler." Among ants the same broad principles hold, but here the family odour retains its importance.

What then are the organs by which insects recognise these odours? Dr. McIndoo has identified them as small pores scattered or grouped on the body and appendages. A nerve ends in each pore, and the opening is often protected by a hair. By covering the pores, experimental proof of their olfactory function was obtained.

That bees, among other insects, can discriminate between foods is well known, and that their power of discrimination exceeds that of man was experimentally proved by Dr. McIndoo. He ascribes this power, however, not to taste, but to smell. Taste and smell are closely allied, and it is possible that the only difference lies in the organs that respond, the stimulus itself being identical. In bees there appear to be no such organs connected with the alimentary tract, so that the discrimination is probably by smell.

Passing over the sense of touch, we find some novel remarks on the sense of hearing, and an interpretation of certain organs on the antennæ (pore-plates and Johnston's organ) as possibly auditory in function, though the audition can, in that event, be little more than an exaggerated sense of touch.

Whether there are in insects or in any other animals senses of a nature entirely hidden from us, is a question raised by Mr. H. H. Beck in an article on "The Occult Senses in Birds" (reprinted from the *Auk*). In some species of moth, for instance, a female exposed but invisible will soon attract the males of the species. Various explanations of this have been suggested—from Mr. Beck's "mate-finding sense" to wireless telegraphy, but Dr. McIndoo believes that the highly developed sense of smell is enough to account for it. The same faculty surely renders it unnecessary to postulate, with Mr. Beck, a special "food-finding sense," though his story of vultures from eight miles away spotting a freshly-killed dog at the bottom of a sink-hole is certainly uncanny. Then there is the homing sense—the most puzzling of all; but it seems less rational to demand some mysterious force, as Bethe does, than to suppose the exercise of the usual senses more highly developed than a townsman can ever imagine, used simply or in combination, consciously or unconsciously.

One might pass on to consider some curious instincts

set forth in the account of two insects of the orchard, by Mr. R. E. Snodgrass, or to learn a lesson from Prof. Lameere's lecture on the origin of insect societies. Or one might get practical hints on the suppression of insect pests by a better utilisation of birds from Mr. W. L. McAtee, or excite oneself over the adventures in the life of a fiddler crab, so delightfully told by Mr. O. W. Hyman. But we must reluctantly pass all these, and pass too Mr. Bassler on the little Polyzoa, Mr. Gilmore on the mighty horned dinosaurs, Mr. Maxon on the Botanical Gardens of Jamaica, Mr. Safford's strange study of the narcotic Daturas, and the richly illustrated articles on Hopi Indians, modern Mexicans, and racial groups and figures, by Fewkes, Genin, and Hough. We must end, but we permit ourselves the perhaps too obvious comment, that this publication is indeed an admirable example of "the diffusion of knowledge among men."

Our Bookshelf.

Introduction à la géométrie non-Euclidienne. Par Dr. A. MacLeod. Pp. 433. (Paris: J. Hermann, 1922.) 20 francs.

IN the theory of relativity, on which so much has been written during the last few years, one of the main difficulties encountered by most readers is the unfamiliar conception of space and time involved. Apart from the difficulty in the conception of a space-time continuum, the notions that space as we know it may possibly be only of limited extent, and that the sum of the angles of a triangle is not necessarily equal to two right angles, are apt to prove only too bewildering to readers whose knowledge of geometrical matters is confined to the Euclidean system.

The question whether the axioms imposed by Euclid are necessary for building up a logical system of geometry has long engaged the attention of mathematicians. In the non-Euclidean system, largely developed by Gauss, the absolute, *i.e.* the "circular points at infinity" of Euclidean geometry, is replaced by a non-degenerate conic. All this entails revised definitions of such terms as "distance" and "right angle."

Dr. MacLeod in the work before us presents the subject with strict logical precision, the reasoning which leads to the various results being given fully and accurately. The actual amount of ground covered is not so great as in Mr. Coolidge's treatise, a book which occasionally suffers from over-condensation. Uninitiated readers will be interested in noticing that the proof of a familiar proposition, that the greater angle of a triangle is opposite the greater side, requires six pages of reasoning. The book would have been improved by more diagrams, but these can be supplied without difficulty. It can be recommended as an excellent introduction to the subject.

W. E. H. B.

History of the Theory of Numbers. By Prof. L. E. Dickson. Volume II. (Publication No. 256, Vol. II.). Pp. xxvi + 803. (Washington: Carnegie Institution of Washington, 1920.) 7.50 dollars.

THE arithmetical questions treated by Diophantus of Alexandria, who flourished about the year 250 A.D., included such problems as the solution of the equations

$$x+y+z=6, \quad xy+z=u^2, \quad xy-z=v^2$$

in rational numbers. Little attention was given to this type of problem from Diophantus's time till that of Fermat (1650), the founder of modern Diophantine analysis. The most general arithmetical question to which the peculiar methods of Diophantine analysis apply is the determination of all the solutions in rational numbers of a system of algebraic equations.

$$R_i(x_1, x_2, \ldots x_n)=0, \quad i=1, 2, \ldots m,$$

there being more unknowns than equations. Particular problems of this type have attracted the attention of a very large number of workers.

Prof. Dickson, in the second volume of his History, gives an account of what has been accomplished in this field of thought. Original memoirs have been carefully scrutinised and abstracted. Naturally, in such a compilation, there is much matter which would not now be regarded as of any great scientific importance, and, in fact, the main value of many of the reports is on the side of historical development.

Scientifically, the most important chapters in the present volume are those on (i.) partitions of numbers, (ii.) representation of numbers as sums of squares, (iii.) Pellian equations, (iv.) indeterminate equations of the third degree, and (v.) Fermat's last theorem. It is to be trusted that the mathematical world will duly appreciate the immense amount of labour expended by Prof. Dickson in the preparation of such a book.

W. E. H. B.

Penrose's Annual: The Process Year Book. Review of the Graphic Arts. Edited by William Gamble. Vol. 25. Pp. xvi + 110 + plates + 64. (London: Percy Lund, Humphries and Co., Ltd., 1923.) 8s. net.

MR. GAMBLE, in his editorial review of process work, looks back twenty-seven years to the first volume of this annual and remarks upon the improvement of the process block since then. He considers that it is now so perfect that there is little if any possibility of advance in this direction. "The signs of the times are that the process block has passed its prime and that there will be a slow and steady diminution of its employment." Rotary photogravure and off-set lithography are improving, and collotype is reviving, its most important application being in the highest grade of colour work.

The superseding of type composition by a photographic method occupies a prominent position in the volume. The "photoline process" of Mr. Arthur Dutton, though the machinery for it is not yet on the market, is so far perfected that we have here good examples of solid text, tabular matter, title pages, ornamental work, and a demonstration that any size of letter can be obtained from one master alphabet.

The body of the book contains several articles of exceptional value following the editor's general summary. Mr. Stanley Morison contributes a long and well illustrated historical article on "Printing in France," and "Printing in China" is dealt with in a

shorter contribution by Mr. Gilbert McIntosh. There is also a note on the Garamond Type, with several examples of it. The illustrations representing process work are, as usual, numerous and very diverse. They include a reproduction from an impression of a wood engraving by the swelled gelatine method and a half-tone direct from Nature. Altogether it is a very interesting volume.

The Psychology of Thought and Feeling: A Conservative Interpretation of Results in Modern Psychology. By Dr. C. Platt. Pp. x+290. (London: Kegan Paul, Trench, Trubner and Co., Ltd., 1921.) 7*s.* 6*d.* net.

THE author's claim in the sub-title is, on the whole, justified. The social and educational bearings of the subject are kept in the foreground; technicalities and controversial or metaphysical problems are, for the most part, avoided. On these terms, as stated in the preface, one is not led to expect more than one finds—a presentation that includes much of the newer teaching but does not break touch with older methods of treatment. The trouble, perhaps, is that if "metaphysical" problems be avoided the result is likely to be an emulsion in which the drops do not combine though they may be swallowed together. If we elect to follow M. Bergson and call the great life-urge the *élan vital*, the concept of nerve-force or neurokyme and that of unconscious cerebration can scarcely coalesce therewith; and if the nerve-force be said to leap a microscopic gap at the synapse, and if it be also said that at each of these gaps, a choice presents itself, the two statements do not seem to be "metaphysically" *in pari materia*. The author is doubtless not less aware than any of his readers of the difficulties that must arise if the more fundamental issues be passed over. For the most part he gives a reading of the facts which will be found sufficiently free from extravagance as to be spoken of as conservative.

Researches on Cellulose. By C. F. Cross and C. Dorée. IV. (1910–1921). (Vol. 4 of the Series "Cross and Bevan.") Pp. x+253. (London: Longmans, Green and Co., 1922.) 15*s.* net.

"CROSS AND BEVAN" are two names inseparably connected with our knowledge of cellulose. The present volume is a continuation of a series of monographs on the subject. Although the properties of cellulose are of such immense importance in nearly all branches of industry, the complexity of the subject is so great that, in spite of a considerable volume of valuable research, there are still many obscure regions. The authors have brought together the results of research carried out by various workers, with helpful and constructive criticism. The result is a very useful monograph, which will be of great value to workers in this field.

The Psychology of Day-Dreams. By Dr. J. Varendonck. With an Introduction by Prof. S. Freud. Pp. 367. (London: George Allen and Unwin, Ltd.; New York: The Macmillan Company, 1921.) 18*s.* net.

THERE is much in Dr. Varendonck's book which will be of interest and of value to psychologists not only of the newer schools but also to those who are nowadays spoken of as "academic." The central aim is to disentangle under distinguishing analysis the part (1) played by "affective thinking" (or what Prof. Freud in the introduction prefers to call "freely wandering or phantastic thinking") in normal life, from (2) that which is played by psychical processes in which a higher order of reflective thinking takes some share. To this end, day-dreams are discussed with much patience and insight. The conclusion reached is that affective thinking may take place in the three levels of consciousness, but that unconscious and fore-conscious thinking are always affective. Where so much turns on the rôle of the affect, chapters on its relation to memory, apperception, ideation, and visualisation, and one on the issues of affective thinking, are helpful to an adequate grasp of the author's position.

The Common Molluscs of South India. By J. Hornell, Director of Fisheries, Madras. Report No. 6 of 1921, Madras Fisheries Bulletin, vol. xiv., 1922, pp. 97-215. (Madras: Government Press.) 1 rupee.

MR. HORNELL has arranged for the preparation of wall-cases containing collections of the common species of molluscs and crustacea for the use of secondary schools in India, and this useful handbook was written primarily as a descriptive guide to accompany the case of molluscs, but the needs of collectors who take an interest in the things they find on the shore have also been kept in mind. Mr. Hornell records the external features, the bionomics, the changes in form of the shell as growth proceeds, the character of the spawn, the use of molluscs as food, and the shells, opercula, pearls, etc., as articles of commerce.

The Evolution of Atoms and Isotopes. By W. D. Verschoyle. Pp. 40. (London: J. J. Keliher and Co., Ltd., Craven House, Kingsway, 1922.) 1*s.* 9*d.*

THE author of this pamphlet proposes, with the help of a bi-polar electron, to explain the evolution of atoms and to abolish positive electricity. He has been stimulated by the discovery of isotopes to develop further a series of numerical relations between atomic weights, some of which have already been described in the *Chemical News*.

An Introduction to Forecasting Weather. By P. R. Zealley. Pp. 32. (W. Heffer & Sons, Ltd., Cambridge; London: Simpkin, Marshall & Co., Ltd., 1922.) 1*s.* net.

THE pamphlet treats the subject of forecasting in an elementary manner, and may interest amateur meteorologists who have receiving sets for radio-telegraphy. The author is a technical assistant in the Meteorological Office stationed at Shoeburyness, and would be conversant with the official weather publications.

Ministry of Munitions and Department of Scientific and Industrial Research. Technical Records of Explosives Supply, 1915–1918. No. 9: *Heat Transmission.* Pp. iv+48. (London: H.M. Stationery Office, 1922.) 5*s.* net.

THIS report embodies in charts and formulæ the experiences of the Department of Explosives Supply on the transmission of heat to or from fluids flowing along pipes under various conditions, and will be found useful by engineers.

Letters to the Editor.

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

Broadcasting Transmitter.

I EXPECT that broadcasters would find that a definite generator of E.M.F. would give cleaner articulation than is probable with a transmitter depending on random variation of resistance. In other words that one of those telegraphic devices which I described long ago (Proc. Inst. E.E., vol. 27, p. 838, Dec. 1898), consisting of a light stiff coil of fine wire suspended elastically in an annular magnetic field, would reproduce speech and music better than a microphone. The fluctuations of the induced current in such an instrument are not capricious, and apart from stimulation it is silent; always provided that the exciting magnetic field is kept steady—a condition likely to be assisted by saturation of the iron magnet core, or by use of a sufficiently strong permanent magnet.

If an electromagnet is used, some contrivance is advisable whereby the coil circuit is automatically opened whenever the rousing current is put on or off. Otherwise, the response may be too violent for the valve and rest of the apparatus, not to mention a receiving ear. OLIVER LODGE.

Normanton House, Lake, Salisbury.

The Green Flash at Sunset.

SIR ARTHUR SCHUSTER in his review of Dr. Mulder's book on this subject states that "there seems no reason to doubt that dispersion combined with absorption of light completely accounts for the effect" (NATURE, September 16, p. 370). Yet Dr. Mulder's own view is that a complete explanation is still wanting.

My apology for again raising this question is that I believe I can supply from some recent observations what seems to be lacking in the dispersion theory, which fails to account for the remarkable variations in visibility of the green flash under apparently favourable conditions.

On the outward voyage to Australia to observe the solar eclipse of September last, I was struck with the faintness of the green flash at sunset, although the sky was clear down to the horizon. It was visible in binoculars (×8), but scarcely, if at all, to unaided vision. On the return journey, on the other hand, the phenomenon was brilliant every evening on the run between the north-west coast of Australia and Java, and I was able to observe also what happened when Venus set in the sea. On this voyage the ordinary mirage effect was conspicuous, that is, distant land appeared raised above the sea horizon by a small interval, due to the total reflection of sky and land at the surface of a thin layer of air of low density in contact with the sea. At sunset the last segment of the disappearing limb was similarly reflected and reversed, causing a lenticular shape with the cusps raised about a minute of arc above the horizon. The green flash occurred when the green-edged cusps coalesced into a single bright patch, and this on one occasion turned to violet at the last moment.

The striking thing about the setting of Venus was the sudden appearance of a reflected image moving upwards to meet the descending image, and the instantaneous and conspicuous change of colour from dull red to green at the moment of meeting of the two images. The vertical spectrum of the planet caused by atmospheric dispersion was at no time visible in the binoculars, but the change of colour was probably due to the setting of the lower red of the spectrum.

It seems to me evident from these observations that the mirage layer greatly intensifies the ordinary dispersion effect, by adding the light from the reflected image to the direct image at the moment of setting. The normal dispersion effect at sunset under conditions when there is no mirage is scarcely visible to unaided vision, although easily seen in a telescope of low power. J. EVERSHED.

Kodaikanal Observatory, September 26.

Thermal Opalescence in Crystals and the Colour of Ice in Glaciers.

IN a previous communication to NATURE (vol. 109, page 42) it was pointed out that the thermal agitation of the atoms in crystals causes optical heterogeneity which should give rise to a noticeable scattering when a beam of light is sent through the substance, and that this effect may actually be observed with suitable arrangements in clear quartz or rock-salt. I have recently found that the same phenomenon is conspicuously exhibited by ice. If a block of clear ice, free from air-bubbles, striæ, or other obvious inclusions, and having flat sides, be held squarely and a narrow pencil of sunlight concentrated by a lens be passed through it, the track of the pencil shows a beautiful blue opalescence. It is advisable not to use a very highly-condensed cone of rays, as this would cause internal melting of the ice with formation of cavities which reflect white light and distract the eye. A dark background should be provided against which the track may be viewed. With small or irregular lumps of ice, the observation may easily be made by immersing the ice in clear distilled water contained in a glass flask which is painted black outside, windows being provided for ingress and egress of light and for observation of the opalescent track. Even with ice which at first looks unpromising owing to internal flaws or inclusions, portions in which the blue opalescence is not overpowered by disturbing effects may be picked out. A suitable orientation of the block with reference to the direction of the incident rays is often useful in avoiding reflections from cavities in the ice.

A comparison of the relative scattering powers of clear water and of ice at 0° C. is instructive. According to the measurements of Bridgeman, the compressibility of ice is 35×10^{-6} per atmosphere, and its refractive index is 1·310, while the corresponding figures for water are 52×10^{-6} per atm., and 1·334. The Einstein-Smoluchowski formula gives the scattering power of water at 0° C. as 144 times that of dust-free air, and if it could be applied in the case of solids, the scattering power of ice should be 79 times that of air. As has already been pointed out, however, the formula has to be modified in the case of crystalline solids, and a revised calculation indicates the scattering power of ice as about 30 times that of air, which is of the order actually observed in experiment.

The atomic scattering of light in block-ice demonstrated and measured in these experiments should certainly be capable of being observed on a large scale under suitable natural conditions. Indeed, it is well known that masses of ice in glaciers and icebergs often exhibit a blue colour, and it appears to the writer very significant that the circumstances in which natural ice shows a blue colour are precisely those found to be

necessary in the laboratory in order that the blue opalescence due to internal scattering may be satisfactorily observed, that is, that the ice should be of the maximum clearness and transparency; in either case, air-bubbles, striæ, and other inclusions obscure the effect sought for. The inference that the phenomena arise in the same way seems legitimate.

I am aware that a different explanation of the colour of natural ice has been put forward by Tyndall and other writers, that is, that the colour is simply an absorption effect. To me, however, it appears that the latter view presents fundamental difficulties. *Prima facie*, no substance can exhibit colour *in its own body* except as the result of internal diffusion or scattering. Colour due to simple absorption can only be perceived when a luminous object is viewed through the substance, and even then it is the source, not the absorbing medium, that appears coloured.

The absorption theory thus leaves it unexplained why clear ice should exhibit any colour at all. Indeed, it would appear that the colour of ice is often very conspicuously observed when the light traversing it has no chance of reaching the observer's eye directly. Thus, for example, in his lecture on ice and glaciers, Helmholtz describes very vividly the experience of the Alpine traveller who, traversing the broken surface of the glacier along a narrow ridge, looks down into the crevasses on either side and views with mixed feelings of pleasure and awe their dark blue walls going down to the depths. It is obvious that in such a case as this, the light filtering *down* into the solid mass of transparent ice forming the glacier through the superficial layers or otherwise, has no possibility of returning to the observer above except as the result of internal scattering.

The natural view to take is therefore that the blue opalescence is the real cause of the colour of transparent ice observed under such conditions, the absorption of light in traversing the medium tending merely to diminish its intensity and make it of a more saturated hue.

C. V. RAMAN.

210 Bowbazaar Street, Calcutta,
November 9.

The Cause of Chambering in Oysters and other Lamellibranchs.

THE phenomenon of chambering in oysters and other lamellibranchs is well known, and in oysters is a source of much financial loss to some oyster planters. In a chambered oyster one extensive closed chamber or several superposed large chambers may occur enclosed within the shell substance—usually in the convex valve, but sometimes in both valves. The chambers are separated from each other or from the body of the oyster by thin brittle partitions of shell only, and contain usually an evil-smelling liquid. When a chambered oyster is opened, great care is required lest the brittle wall of the chamber be broken and the evil-smelling liquid released on the oyster, which would in that case be rendered unfit for eating.

The cause of chambering has recently been described by Houlbert and Galaine (*Comptes rendus*, Acad. Sci. Paris 162, 1916), not as "un accident pathologique . . ." but "comme la persistence d'une propriété ancestrale." Later, these writers suggest inanition as a cause. In our recent investigation on oysters we have observed several phenomena which when pieced together offer a rational explanation of chambering as a minor pathological phenomenon due to varying external conditions coincident with variations in the internal condition of oysters.

We have observed that when oysters are kept in bell-jars or dishes in a warm room in the laboratory without food in winter they begin to grow shell automatically, whereas in the sea in a normal winter no growth of shell occurs; moreover, oysters kept in the laboratory in summer may continue to lay down shell at a rapid rate although food is practically absent. In such oysters it frequently happens that owing to the unfavourable conditions of transport in summer weather the oysters arrive in a bad condition, one of the effects of which—combined with the effect of the laboratory water—is to cause the oysters to shrink somewhat in their shell, but especially to contract the mantle, whereby puckers are formed in it. Now, although the mantle and body shrink, the layer of the mantle and body next to the shell continues to secrete shell substance in a thin layer. As a consequence of these conditions the oysters lay down on the inside of the shell a thin layer of shell-substance in an irregular manner, following especially the puckerings of the mantle. This thin layer of shell is laid down with a water space between it and the shell, and is, in fact, a small chamber. The same process occurs, as is well known, when mud gets into the shell accidentally, or when a hole is punctured in the shell and is afterwards plastered over with repair shell inside. The above facts show that shell is laid down automatically by the mantle and body surface adjacent to the shell if the temperature is sufficiently high and—it may be added—if the oyster is in reasonably good condition.

The second observation is well known to oyster-cultivators, namely, that oysters will swell considerably in water of low salinity and shrink in water of high salinity. This change occurs probably through the readiness of the bladder-tissue in lamellibranchs to respond and accommodate itself to changes in osmotic pressure. Now, chambered oysters occur most commonly on beds in high estuarine or riverine situations, where the salinity variations are great. The third factor of interest in this problem is that oysters vary greatly seasonally in weight, and, it can be safely deduced, in volume as well: very low salinities due to heavy rains would certainly also reduce the amount of available food-material for oysters. We have also observed that when oysters are kept for some months in tanks in stagnant water, the salinity of which thereby increases considerably, the percentage of chambered oysters is afterwards found to be very high and the bodies of the oysters shrink to a very great extent. The last factor of importance is this, that the rainy period in England falls either in the early part of the year or at the end of the year, while the month of May is fairly dry; but in May and June oysters prepare or begin to breed, and it becomes warm enough normally for shell to grow.

These observations may now be pieced together. In the early months of the year in high estuarine or riverine beds oysters are frequently subject to low salinities, *e.g.* 15 per cent. or even lower; towards May or June higher salinities will generally occur in these situations together with the onset of breeding among oysters; both these factors tend to reduce the volume of the body of the oyster, and—it has been noted—at a time when it is warm enough for shell-growth to take place. If the oyster is in good condition, shell-growth—it has been observed—occurs automatically. Thus, as the volume of the oyster is shrinking in these situations, shell material is being produced, consequently a shell lamina which is not adjacent to the existing body of the shell is laid down and a chamber results. Water probably forms in the chamber by percolation along the outside of the body of the oyster between the body and the shell. In this way are probably included in the chamber

various organisms—present in the sea-water—which give rise to the unpleasant smell. The principal organisms concerned would appear to be the well-known anaerobic bacteria which produce hydrogen sulphide.

The cause of chambering among oysters on beds in high estuarine situations can therefore be stated to be the reduction in bulk of the body, which occurs at the shell-growing period in these situations from a variety of causes, of which the decrease of bulk due to breeding and salinity variations are the most important.

It may be noted, however, that chambering is rare on what are regarded as good oyster beds, and there is good reason to believe that the salinity variations over such beds range between about 30 and 34 per mille.

Chambering has also been observed in some deep-sea oysters, and, it may be presumed, from the operations of the same causes as in high estuarine situations. The conditions on deep-sea oyster beds are very different from those in high estuarine situations, but the breeding phenomena on the former beds are not known. It seems probable that breeding may not occur at all in some years in deep-sea beds, or that there is only a short breeding period (see Orton, Journ. Mar. Biol. Assn. vol. 12, p. 343), but that on the other hand growth is probably continuous over the greater part of the year. Since salinity variations would not be great on deep-sea beds it would appear that the reduction in bulk of the body due to breeding coincident with extensive shell-growth (see Hoek, Report on the Causes of the Deterioration in Quality of the Zealand Oyster, p. 90, s'Gravenhage, 1902) is the main cause of chambering in deep-sea oysters.

The view given above on the cause of chambering in oysters could readily be put to the test of experiment, but it would be preferable to carry out experiments on a large scale, beginning with thousands of young oysters. The economic importance of oysters is sufficiently great for the matter to be taken up by such large oyster-planters as are troubled with chambering. It will readily be seen from the argument given above that chambering is a minor pathological phenomenon, and that there is nothing to prevent the growth of a good well-fished oyster in a chambered shell, and, as a fact, excellent oysters do occur in chambered shells.

EDITH WORSNOP.
J. H. ORTON.

Marine Biological Laboratory,
Plymouth, December 4.

The Hardness of Vitreous Silica.

THE hypothesis proposed by Sir George Beilby to account for the hardening of metals by cold-working, and accepted by most metallurgists in this country, assumes the production of a vitreous phase of the metal by the breaking down of the crystalline structure during extensive deformation. It requires that the vitreous modification of a substance should be harder than the crystalline. Direct evidence on this point has rarely been obtained. Silica, however, suggests itself as a suitable substance for such a test, both the crystalline forms and the under-cooled glass being readily obtained in a form suitable for mechanical tests. The hardness of silica was carefully studied by Auerbach, who found a surface of vitreous silica to be less hard than either of the principal faces of quartz. Most commercial silica glass is, however, so weakened by the presence of numerous gas bubbles that any grinding test is likely to give low results for the hardness.

We have recently had the opportunity of examining a specimen of silica of unusual hardness. This was obtained by throwing a quantity of pure quartz sand on to the slag in an open-hearth steel furnace when the slag surface was at an exceptionally high temperature (1800° C. by the optical pyrometer). The sand melted, and formed a lenticular mass, which only mixed with the slag at its margin. On removing the product, a colourless, translucent mass of glassy silica was obtained, passing sharply into the dark slag. Analysis of the colourless mass gave 97·7 per cent. silica, 2·0 per cent. lime, and a trace of iron. A thin section between crossed Nicols was isotropic, with only a few scattered inclusions of minute crystals and some spherical bubbles.

Tests with a sclerometer, using a diamond point under a load of 400 grams, gave a broader scratch on a prism face of quartz than on a polished surface of the vitreous silica, but on account of the splintery nature of both scratches little reliance could be placed on the actual measurements. A fractured edge of the fused product distinctly scratched the prism faces of quartz, while natural angles of the latter failed to scratch the vitreous surface. Further tests were made with the scleroscope, an instrument in which the rebound of a diamond-pointed hammer falling from a height is measured. The following figures were obtained, all the specimens being embedded in pitch in the cast-iron cup provided with the instrument:

Polished vitreous silica	94
Quartz, prism face	91
Commercial vitreous silica . . .	82

The experiments are not conclusive, and a higher accuracy will be attempted, but it would appear that silica thoroughly fused at a high temperature is distinctly harder than crystalline quartz, and to this extent the experiments support Beilby's hypothesis.

COSMO JOHNS.
CECIL H. DESCH.

Sheffield, December 2.

Distribution of the Organ-Pipe Diatom, *Bacillaria paradoxa*.

IN the Notes in NATURE for September 29, 1921 (vol. 108, p. 163), it is mentioned that Mr. J. W. Williams and Mr. H. Weaver have found the curious organ-pipe diatom, *Bacillaria paradoxa*, in canals and pools in Staffordshire and Worcestershire. It may be of further interest to note that while leading a party of field naturalists on a seaside expedition to Altona Bay, near Melbourne, some years ago (*Victorian Naturalist*, vol. xxxiv., June 1917, p. 16), we found this same diatom very abundantly both in the sea and up the Kororoit Creek for a good distance, where the water was only slightly brackish. On examining the finds at home I was struck with the fact that, whereas the marine form was very active in its peculiar sliding movement, the brackish form was sluggish in contrast. It would be interesting to know whether other observers have found the fresh water to act as an agent for "slowing down." Probably the saline conditions of the water assisted the osmotic pressure which may induce the movement.

F. CHAPMAN.

National Museum, Melbourne,
October 24.

Speculation concerning the Positive Electron.

SIR OLIVER LODGE'S interesting speculation, in NATURE of November 25, p. 696, as to the possible similarity of positive and negative electrons suggests an inquiry into the relative abundance of the lighter

and heavier elements to be expected on this hypothesis. Considering the simplest case, that of hydrogen, let us assume that very large equal numbers of positive and negative electrons initially combine to form $N+n$ positive, and $N-n$ negative protons, and that the negatives immediately combine with an equal number of positives to form heavier nuclei, leaving $2n$ positive protons to form hydrogen atoms. Since in the combination of protons to form heavy nuclei the loss of mass by "packing" is apparently small, the ratio $\frac{\text{mass of hydrogen}}{\text{total mass of all elements}}$ should be very nearly equal to $2n/2N$, *i.e.* n/N.

The probability that, in the fortuitous formation of $2N$ protons, $N+n$ shall be positive and $N-n$ negative is $\frac{(2N)!}{2^{2N}.(N+n)!.(N-n)!}$. This is a maximum when $n=0$. Call this probability for an exactly equal distribution P, then the probability for any other distribution is $\frac{P.(N!)^2}{(N+n)!.(N-n)!}$, which, in the limit when N is very great, reduces to $Pe^{-\frac{n^2}{N}}$. It is hence highly improbable that n^2 should be large compared with N. If we assume that $n^2=N$ we should get a result of the right order of magnitude. On this assumption the relative concentration of hydrogen would be $1/\sqrt{N}$.

Whatever may be the case in other systems, we would certainly seem to be justified in assuming that, in the solar system, all, or almost all, the atoms are of the positive nucleus type. The number of protons constituting the solar system is about $1{\cdot}2\times10^{57}$, which would give a hydrogen concentration of the order of 4×10^{-29}. As the hydrogen in the terrestrial oceans forms 8×10^{-11} of the whole mass of the solar system, there is no need to enlarge upon the magnitude of the discrepancy. A similar argument might be applied to the other light elements formed by the combination of positive and negative protons.

The above argument may be objected to on the ground that some negative protons would certainly combine with previously formed positive complexes. As, however, about half the complex nuclei first formed would be negative, so that some of the positive protons would be lost by combination with them, we would expect these effects to balance approximately, unless we assume that, when two unequal nuclei combine, the sign of the combination is determined by that of the larger constituent. On this hypothesis it is conceivable that, if the first set of nuclei formed happened to be positive, they might so direct the course of subsequent events by annexation of negative protons, and light negative nuclei, as to lead to the existing distribution of the elements.

HORACE H. POOLE.

Royal Dublin Society,
Leinster House, November 29.

The Hæmoglobin Distribution on Surfaces of Erythrocytes.

FROM time to time the point is brought home that factors should be discarded only when exact calculation proves them to be negligible. A case in point is the recent paper by Dr. K. Burker (Pfluger's *Archiv für die gesamte Physiologie*, vol. 195, p. 516). In this interesting paper it is shown that in mammals the weight of hæmoglobin per square micron of surface of the erythrocytes is apparently a constant equal to $31{\cdot}7\times10^{-14}$ gm. Dr. Burker has, however, assumed that the surface area of the cells is equivalent to twice the area of a circle having for its diameter the large diameter of the cell. The general opinion is that in mammals (the camel excepted) the shape of the cells is a bi-concave disc, having a circle for its horizontal projection, and a flat bi-concave ellipse for the vertical projection of which the minor axis is about one-third of the major axis (E. Ponder, Proc. Roy. Soc. 94B, p. 102). The surface area of such an erythrocyte would then be equal to that of an ellipsoid of revolution around the minor axis. It can be shown by the integral calculus that the area of such an ellipsoid (if the minor axis is equal to one-third the major) is $1{\cdot}09$ times as great as that of two circles with the major axis for diameter. Dr. Burker's constant is therefore equal to $31{\cdot}7/1{\cdot}09$ or 29×10^{-14} gm. hæmoglobin per square micron of surface of erythrocyte instead of $31{\cdot}7\times10^{-14}$ gm.

BENJAMIN S. NEUHAUSEN.

Department of Physiology,
Johns Hopkins University,
Baltimore, Md., November 24.

The Local Handbook of the British Association.

I HAVE just seen Mr. Bernard Hobson's letter in NATURE of November 4, p. 605. Mr. Hobson might have finished the quotation he gave from your review of the Hull Handbook which stated that "It approaches nearer to our ideal than that issued at any previous meeting. . . ."

Early last year Mr. Hobson wrote to me making various suggestions in connexion with the handbook, and I fancy I was able to tell him that they had all been carried out: he has now found some more. Of course no one will be able to meet the wishes of every member of the British Association in this way, but what is often forgotten is the fact that the local handbook is *presented* to the visitors *by the local committee*, and whether it is good or bad is scarcely the concern of a committee of the British Association. In our case something like 800*l.* was spent in producing a book which, we knew quite well, could not possibly be read, marked, learned, and inwardly digested during the meeting, but we felt that the book might be useful for reference after the return of the members to their respective homes.

I quite agree that an index and a geological map would have been an improvement; in fact, we went to considerable trouble in the preparation of a geological map of the Riding, but the printers' strike made its publication, indexing, etc., impossible. Only a few days before the Hull meeting none of the handbook was printed off, much was still in manuscript, and it was only by working day and night that a supply was ready for the use of the members. For the benefit of future meetings of the Association, may I suggest that the editor of the handbook should not be one of the local secretaries. Each of these tasks is quite sufficient for an ordinary human being, and for one to attempt both is almost bound to court disaster.

T. SHEPPARD.

Museum, Hull.

Occult Phenomena and After-images.

PROF. ANDRADE'S experiments recorded in NATURE of December 23, p. 843, on the apparent movements of cardboard hands, suitably illuminated by dim light, are interesting in connexion with a phenomenon recently recounted to me by a coroner of long experience. It appears that members of the jury, when brought in to view a corpse, frequently declare that they have seen the body, sometimes of long standing, breathing. No doubt an apparent up and

down movement of the naked thorax is induced in a way similar to that recorded by Prof. Andrade. It is possible that murderers brought into the presence of the corpse of their victim exposed in a dim light must frequently have seen such movements of the hands especially as they will probably stare fixedly at the body. Any apparent movement will of course be intensified by suggestion. This may account for many old superstitions.

Finally I should like to compliment Prof. Andrade on having described certainly two of the prettiest methods of demonstrating the movements of the visual purple. I find that the phenomena described by him are readily seen by people who have not been told what they are expected to see, an essential point in such experiments.

F. W. EDRIDGE-GREEN.

London, December 26.

Experiments on Hardness and Penetration.

I AM greatly interested in the letter on "A Curious Feature in the Hardness of Metals," by Mr. Hugh O'Neill and Dr. F. C. Thompson, which appears at p. 773 of NATURE of December 9, for in my paper "Experiments with Clay in its relation to Piles," read before the Society of Engineers on March 10, 1919, will be found an account of the "pressure of fluidity" of clay. Briefly this may be described thus. When a horizontal disc resting on clay is gradually loaded it slowly sinks into the clay, each increment of load producing a corresponding increment of penetration, but when the load on the disc reaches a certain critical value the disc continues to sink at about ten times the speed *without* any further increase of the load. This load divided by the area of the disc I have called the pressure of fluidity of the clay. This quantity has been found, within a considerable range, to be independent of the area of the disc used for its determination. The only factor upon which it depends, in the case of the London clay used, is the percentage of water in the clay, and by this it is very greatly affected, as will be seen from the following equations, which fit the results closely within the ranges stated, and the table below.

From 28 per cent. to 38 per cent. of water; $p' = \frac{1073 \times 10^{10}}{(w')^7}$, where p' is the pressure of fluidity in grams per sq. cm. and w' is the percentage of water in the clay.

The same equation may be used with small error down to $w' = 25{\cdot}7$ per cent., but with values of w' from 25·7 per cent. to 22·0 per cent. the relation is p (kilograms per sq. cm.) $= 39{\cdot}5 - 1{\cdot}48w'$.

I have experimented with spheres in place of discs and have not detected any difference in the values of the pressures of fluidity thus determined. The reason for this is probably due to what other experiments have disclosed, namely, that the descending disc carries down with it the clay which was immediately under it at the start of the experiment, this stagnant clay forming roughly a hemisphere below the disc. Whether a disc or sphere is used, a clean hole is left behind.

Expecting to find a similar phenomenon in the case of metals, a corresponding experiment was made with cast lead. The result was the same. At a certain critical load the disc continued to sink into the lead without further increment of load. The pressure of fluidity of lead was thus found to be 1233 kilos per sq. cm., as recorded at pp. 152-4 of my fourth paper on "The Physical Properties of Clay," read before the Society of Engineers on June 12, 1922. From the rate of penetration (after the pressure of fluidity had been reached) and by a modification of Stokes' Law, the viscosity of the lead at 60° F. was found to be

$7{\cdot}37 \times 10^{10}$ dyne-seconds per sq. cm.

Taking the Brinell formula given by Messrs. O'Neill and Thompson, when the ball is below the surface of the material $d = D$, and the Brinell formula they give becomes

$$H = \frac{2L}{\pi D^2}. \quad . \quad . \quad . \quad . \quad . \quad (1)$$

And when $d = D$ the Meyer formula becomes

$$L = aD^n. \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Substituting (2) in (1) we have

$$H = \frac{2aD^n}{\pi D^2} = \frac{2a}{\pi} D^{n-2}. \quad . \quad . \quad . \quad (3)$$

The Brinell hardness number is the stress in kilograms per sq. mm. on the curved surface of the indentation.

The pressure of fluidity, p, is the critical load L divided by the area of the disc (or great circle of the ball). Thus:

$$p = \frac{L}{A} = \frac{L}{\frac{\pi}{4}D^2} = \frac{aD^n}{\frac{\pi}{4}D^2} = \frac{4a}{\pi} D^{n-2}. \quad . \quad . \quad (4)$$

Hence p is seen to be equal to 2H, where $H = \frac{2L}{\pi D^2}$ and L is the critical load.

This result also immediately follows from the fact that in the case of the Brinell No. the load is divided by the area of the *curved* surface of the indentation, whereas in the case of the pressure of fluidity the load is divided by the projected area of the sphere, and the ratio of the area of the curved surface of a hemisphere to its flat surface is 2.

$$\text{As } A = \frac{\pi}{4}D^2, \quad \therefore D = 1{\cdot}13\sqrt{A},$$

Therefore Meyer's formula

$$L = aD^n \text{ becomes } L = a(1{\cdot}13\sqrt{A})^n$$

$$= a(1{\cdot}13)^n A^{\frac{n}{2}}.$$

But in the case of clay, $L \propto A$, this being one of the most definite and carefully determined results. Consequently, if Meyer's formula is also true for clay, n must be $= 2{\cdot}0$, in which case $L = a(1{\cdot}13)^2 A = 1{\cdot}275aA$, and $L/A = p = 1{\cdot}275a$ or $a = p/1{\cdot}275$.

Using this relation the following values of a are obtained for London clay:—

Per cent. of Water.	Pressure of Fluidity. Kilos per sq. cm.	a.
37·8	0·107	0·083
37·0	0·128	0·100
31·0	0·320	0·251
30·0	0·527	0·414
29·0	0·600	0·471
28·0	0·846	0·663
25·4	1·938	1·521
23·6	4·700	3·69
22·0	7·200	5·65

A. S. E. ACKERMANN.

17 Victoria Street, Westminster, S.W.1,
December 11.

The Borderland of Astronomy and Geology.[1]

By Prof. A. S. EDDINGTON, F.R.S.

THE region in which geology and astronomy most conspicuously overlap is in the theories of the origin of our planet. We have, in fact, two main theories—one due originally to an astronomer, Laplace, and the other to a geologist, Chamberlin.

In the last century the evolution of a star seems often to have been regarded as something quite detached from the evolution of the stellar universe. Just as the birth and death of a man is an incident which can occur at any time in the rise and decline of the human race, so it was thought that the birth and extinction of a particular star formed merely a detached incident in the course of progress of the stellar universe—if, indeed, the universe was progressing in any particular direction. Thus it was a natural belief that the stars died out and were re-formed by collisions of extinct stars; and that the matter which now forms the sun had undergone many alternations of incandescence and extinction since things first began. But this view is quite at variance with the general tendency of sidereal astronomy in the present century. We have come to recognise that the stellar system is one great organisation, and that the stars which are shining now are more or less coeval with one another. Everyone would admit that Mars and Jupiter were formed as parts of one process of evolution—not necessarily at the same moment, but each formed as the process reached the appropriate stage; and similarly we now believe that it was one process of evolution sweeping across the primordial matter which caused it to form itself into stars; and these original stars are the actual stars which we see shining now. No doubt the evolution did not develop at the same rate in all parts of the universe, and there are probably places where stars are still being formed; but you will see that this view is entirely different from the other view that stars were being formed individually by haphazard collisions of dark stars, so that each was an independent formation, having no time-connexion with other stars.

This view has been forced on us partly by direct evidence of organisation among the stars, pointing to a common origin for large groups of stars. We notice scattered groups such as the Hyades, which have almost exactly equal and parallel motions. Clearly it would be impossible to form such a group if each star were the product of an accidental collision. The only way in which a common motion like this can arise is by associated development from some nebula or other diffuse distribution of matter. The connexion is clearly a connexion of common origin. Again, practically all the bright stars of Orion form a similar group, having common motion; and, moreover, they have all reached a similar stage of evolution. They are connected with the great Orion nebula, the faint extensions of which fill up nearly the whole constellation. It is obvious that here we have to deal with a single evolutionary development. But another point which militates against a collision theory is the extreme rarity of collisions and close approaches. The distances separating the stars are enormous compared with their own dimensions. Sir Frank Dyson once used the illustration of twenty tennis-balls, distributed at random throughout the whole interior of the earth, to give a model of the density of distribution of the stars. It has sometimes been objected that we do not know how many extinct stars may be wandering about and colliding. Dyson's twenty tennis-balls represent only the *luminous* stars; there may, for all we know, be millions of *dark* bodies ready to be fired into incandescence by collision. I think, however, that there is now good evidence, based on the dynamics of stellar motions, that the dark stars cannot greatly outnumber the luminous stars—probably not ten times and certainly not a hundred times. (If they were more numerous than that, the average velocities of stars would, owing to the gravitational attraction, be much higher than is observed.) That argument, then, is no longer valid. Taking a very liberal view of the kind of approach that can be held to constitute a collision, it is estimated that a star would only suffer collision once in 10^{14} years.

Thus the astronomer is not predisposed to look favourably on a hypothesis of the origin of the solar system which postulates anything of the nature of a collision. He has the conception of an orderly development of the stars crystallising out of the primordial material, and, unless perhaps in exceptional cases, following an undisturbed course of development. We hope for a theory that will show us the star after its first isolation from surrounding material spontaneously developing the system of planets.

It now appears almost certain that, whether the original matter was gaseous or whether it was composed of meteors, it must at an early stage in the star's history have been completely volatilised into gas. This was while the star was extremely diffuse, and, for example, before the planets separated from it. This means that the material now forming a planet has at one time passed through the furnace, and has cooled down from a gaseous stage. How far that has a direct bearing on geology I cannot say, since I have nothing to guide me as to the course of its subsequent chequered history. I do not say that the earth was a gaseous body when it first became recognisable as an independent planet, but I am convinced that its material was at one time merged in a completely gaseous sun.

It may be of interest to indicate why it seems so probable that a star in its early diffuse state is gaseous and not meteoric. The stars are known to be of closely similar mass. There are occasional exceptions, but probably 90 per cent. of them are between one-half and five times the sun's mass. We have no explanation of this uniformity if they are initially merely aggregations of solid meteors; but we have a very exact explanation if they are gaseous. In fact this critical mass round which the actual masses of the stars cluster so closely is predicted by the theory of equilibrium of spheres of gas, using only well-known physical constants determined in the laboratory. The crucial factor is radiation-pressure, which is inappreciable in smaller masses, and almost suddenly takes control between one-half and five times the sun's mass.

[1] A lecture delivered before the Geological Society of London on November 21.

There can be little doubt that large radiation-pressure, tending to overcome gravity, conduces to instability, so that larger masses have small chance of survival. Somewhere about one-half the sun's mass the radiation-pressure no longer counts seriously, so that there is no tendency for the primitive material to break into smaller units.

The existence of radioactive minerals on the earth seems to supply another reason for believing that its material was originally subjected to high temperature or to physical conditions of a different order from those now prevailing. In radioactivity we see a mechanism running down which must at some time have been wound up. Without entering into any details, it would seem clear that the winding-up process must have occurred under physical conditions vastly different from those in which we now observe only a running-down. The only possible guess seems to be that the winding-up is part of the general brewing of material which occurs under the intense heat in the interior of the stars.

The trend of this argument has been against the Chamberlin-Moulton hypothesis and in favour of some form of nebular origin of the solar system. It is, of course, accepted that the details of the original nebular hypothesis of Laplace require modification. Also the word nebula is meant to signify diffuse gaseous material in general, and has no immediate connexion with those objects which we see in the sky, and call nebulæ more particularly. There is still controversy as to what process of evolution is represented by the spiral nebulæ which are seen in such numbers—what they will ultimately turn into; but the controversy is whether the spiral nebula will give rise to a cluster of a few hundred stars, or whether it will turn into a stellar universe on the same scale as the great system of some thousands of millions of stars which forms our galactic system. There is now no suggestion that it has anything to do with the formation of so insignificant a system as the solar system. But in preferring the nebular hypothesis to that of Chamberlin and Moulton, it is necessary to make a certain reservation. We have hitherto taken it for granted that the formation of a system of planets is a normal feature of the evolution of a star. Most of my arguments have referred to the development of stars in general, and would become irrelevant if it could be admitted that the solar system were an exceptional formation violating ordinary expectation.

We know that at least a third of the stars are double stars, and I do not think there is any reason to think that planetary systems would be formed when the evolution takes that course; but until recently it was taken for granted that the remaining single stars would generally (or at least frequently) be the rulers of systems of planets. Jeans has recently pitched a bombshell into the camp, suggesting that the solar system is a freak system—the result of a rare accident, which could only happen to one star out of a very large number. He found no way of accounting for it as a normal process. I have not the specialist knowledge necessary to criticise the details of the working of the nebular or of the planetismal theory of development, but before regarding Jeans's argument as conclusive (he himself makes reservations) I should be more satisfied if the effect of radiation-pressure had been taken into account. It is fairly clear that radiation-pressure plays a great part in the separation of nebulous matter into stars, and although I have no definite reason to think that it can account for the separation of planets from the sun, I do not feel satisfied that we have got at the whole truth until that point has been duly examined.

Supposing, however, that we are forced to accept Jeans's suggestion that the solar system is a freak system, some of my objections to the Chamberlin-Moulton hypothesis are removed. I cannot admit that the conditions of collision which that hypothesis requires are normal features in the formation of stars; but they might have happened occasionally in the history of the universe, and produced the solar system, the sun being thus as an exceptional star born out of due time. But if my arguments against Chamberlin's hypothesis fall to the ground, there are probably other astronomers prepared to attack it in other directions.

The new views as to the age of the earth are now pretty well known to geologists. I may sum them up briefly in the statement that Lord Kelvin's estimate of the extent of geological time need not now be taken any more seriously than Archbishop Ussher's, and that the geologist may claim anything up to 10,000 million years without provoking a murmur from astronomers. Although there may still be some difficulties about the exact source from which the vast heat-energy the stars pour out into space is derived, it is now clear that the Helmholtz contraction-theory is inadequate to give the necessary supply. The astronomer has no such precise means of measuring geological time as the physicist has now discovered by the analysis of radioactive minerals; but he can add his contributory evidence that the sun, and presumably therefore the earth, is much older than Lord Kelvin allowed. In the Cepheid variable stars it seems possible to measure the actual rate at which evolution is proceeding—the rate at which the star is condensing from a diffused state to a denser state. The star is believed to be pulsating, and as it expands and contracts the light varies in quantity and character. In a pulsating gravitating mass the period is proportional to the inverse square root of the density, so that by observing the rate at which the period is changing we can deduce the rate at which the density is changing. I may add that the law that the period depends on the inverse square root of the density is very closely confirmed by comparing the values for the various Cepheids. In this way we find that for the best observed of these stars, δ Cephei, the density is changing 500 times slower than the contraction hypothesis assumes. It would, of course, be risky to assume that the same proportion holds at all stages of the evolution of a star; but it suggests that Lord Kelvin's estimate of 20 million years for the age of the sun might well be multiplied by 500 to give 10,000 million years. At any rate, the Cepheid observations show that the stars must have some other source of energy besides contraction.

I suppose it must be a matter of interest to geologists whether the intensity of the sun's heat has been constant or whether it was at one time hotter than

now. I think we can say fairly definitely that the sun was formerly much hotter. There must have been a time when the sun's heat was from 20 to 50 times more intense than it is now. That would no doubt have made a great difference to many geological processes. Unfortunately, I cannot say whether it occurred in known geological epochs. It must have occurred after the earth had begun to exist as a separate planet; but whether it was before or after the sequence of geological strata began to be laid down I have no idea. It would not be unreasonable, however, to expect that in the early geological times the sun was several times hotter than it is at present.

After the evolution of the solar system, we naturally turn to consider the evolution of the earth-moon system. My impression is that nothing in recent progress suggests any doubt that the beautiful theory of Sir George Darwin is substantially correct. The main features are that the moon at one time formed part of the earth, and broke away. At that time the rotation period of the earth was between 3 and 4 hours, and the cause of the fracture was that the solar tidal force synchronised with a free period of natural vibration of the earth; owing to resonance the tidal deformation of the earth continually increased until rupture occurred. The earth's period of rotation has since lengthened to 24 hours, owing to frictional dissipation of energy by lunar and solar tides; and the back-reaction of the lunar tides on the moon has caused the moon to recede to its present considerable distance. All this has well stood the test of searching criticism, and must be considered as extremely probable. Modern research has added two contributions; it enables us to calculate the magnitude of this tidal friction at the present time, and it enables us to locate more exactly the region where the frictional dissipation is occurring.

I believe it was Darwin's view that the tides most potent in wasting energy were not water-tides but tides in the solid earth; that is to say, we have to do with deformations of the whole earth under the tide-raising force of the moon's attraction. Undoubtedly these deformations of the earth occur, but everything turns on whether the process of deformation is attended with serious friction. H. Jeffreys has pointed out that the phenomenon of latitude variation is accompanied by similar deformations of the earth; and in this case it is clear that the friction is inconsiderable, for otherwise the deviations of the pole from the symmetrical position would be damped out almost at once. It seems, therefore, very unlikely that the solid tides can have had much effect in the process of tidal evolution of the earth-moon system. Ocean tides are likewise of small effect as Darwin himself had seen. The modern conclusion is a very curious one; it is in the land-locked shallow seas that nearly all the mischief occurs. This was discovered by G. I. Taylor, who found that the Irish Sea alone is responsible for $\frac{1}{50}$ of the whole amount required by observation. The remaining land-locked basins on the earth are probably capable of making up the necessary total.

The actual rate at which the earth's rotation is being slowed down at the present era can probably be deduced with fair accuracy from the records of ancient eclipses. The day is lengthening about one-thousandth of a second per century or 1 minute in 6,000,000 years. At this rate we should have to go back more than 10,000 million years to the time when the day was between 3 and 4 hours and the moon was born. Since the rate depends on the accidental circumstance of occurrence of shallow seas no definite prediction can be made; but allowing for the much greater effect of the tides when the moon was nearer to us, it is difficult to date the birth later than 1000 million years ago.

Had the earth a solid crust at the time the cataclysm happened? I cannot tell at all. But if it suits geological theories I can see no objection whatever to the hypothesis that the earth had a solid crust at the time. No cohesion of the crust would seriously resist the enormous forces involved when the resonant vibration got started. It would not be appreciably more difficult than the disruption of a molten earth. The view that the Pacific Ocean is the hollow left at the place where the moon broke off seems tenable unless geologists find objection to it; and in that case we may suppose that the water now collected in the hollow formerly covered the earth—or most of it. This change of condition of the earth may (or may not) have happened within geological times. When the earth was covered with water there would be no land-locked seas and no appreciable tidal friction from the sun (the moon being not yet born), so that we can allow a long previous history during which the length of day was nearly constant at 3 or 4 hours. That rather helps to make the whole theory self-consistent.

These speculations stand very much as they did when Darwin put forward his theory. But I am tempted to add further speculations arising out of the location of the frictional dissipation. (I am taking advantage of the great opportunity for speculation which this address affords. Ordinarily I am restrained, because people would ask, What facts can you produce in support of your speculations? But here I am asking the question, Have you any facts which seem to support them? If not, by all means let them drop.) The frictional dissipation acts as a brake on the earth's rotation, and we now feel confident that the brake is a surface-brake applied at certain points on the earth's surface where the favourable conditions exist. The retarding force is transmitted to the earth's interior, and so delays the rotation as a whole; but unless the material is entirely non-plastic there will be a tendency for the outer layers to slip on the inner layers. I do not know how much the material a few hundred miles below the surface would be expected to give under the strain; it may be inappreciable, but I will assume that though small it has some effect.

We have then the whole crust slipping from east to west over the main part of the interior. Probably it would go very stickily, sometimes arrested by a jamming which would hinder it for a time and then going on more easily. That is helpful in explaining certain astronomical observations. There are irregularities in the motions of heavenly bodies, noticed particularly in the swift-moving moon but shown also on a smaller scale in the sun and planets, which appear to indicate that our standard timekeeper, the earth, is a little irregular. Now, of course, it is the rotation

of the *surface* of the earth which determines our standard time. I find it difficult to believe that there can be irregular variations in the angular velocity of the earth as a whole; but it seems less difficult if the variations are merely superficial, due to the crust sliding non-uniformly on the interior. I have even entertained the wild idea that the motion of the magnetic poles might be due to this cause; the magnetism being constant in the interior but with the axis emerging at changing points of the crust as the crust slips over the inner magnet. Unfortunately, so little seems to be known about the motion of the magnetic poles that I have not even been able to make out whether the motion is from west to east as this theory definitely requires.

What interests the geologist more nearly is that the brake is applied only at certain areas on the surface, so that there would be a tendency to crumple the crust more particularly to the west of these areas. It is unfortunate that shallow seas are necessarily the least permanent features of the earth; otherwise I would have asked whether the geologists had evidence of special crumpling in such areas.

I have regarded the crust as fairly mobile from east to west. I suppose the geologists would also like it mobile from north to south in order to have glacial periods in those portions which are now near the equator. It is not possible to hold out much encouragement for such an idea, because we cannot imagine any force acting from north to south. Still if the crust, which is being urged by the east-west force of tidal friction, is resisted by obstacles it may be deflected, finding that say a south-west track offers less resistance. In a long enough time almost any displacement may have happened, granting my hypothesis that the connexion of the crust to the interior is reasonably plastic. So I cannot forbid this possible interpretation of glacial periods in the earlier geological times.

I am sure that it will not be supposed that, in presenting the astronomical side of these questions which belong both to geology and astronomy, I have any intention of laying down the law. The time has gone by when the physicist prescribed dictatorially what theories the geologist might be permitted to consider. You have your own clues to follow out to elucidate these problems, and your clues may be better than ours for leading towards the truth. We both recognise that we are adventuring in regions of extreme uncertainty where future discoveries will probably lead to various modifications of ideas. Where, as in the new views of the age of the earth, physics, biology, geology, astronomy, all seem to be leading in the same direction, and producing evidence for a greatly extended time-scale, we may feel more confidence that a permanent advance is being made. Where our clues seem to be opposed, it is not for one of us to dictate to the other, but to accept with thankfulness the warning from a neighbouring science that all may not be so certain and straightforward as our own one-sided view seemed to indicate.

Nature and Reproduction of Speech Sounds.[1]

By Sir RICHARD PAGET, Bart.

ALL the characteristics of English speech—the vowels and diphthongs and consonant sounds—can be produced—as breathed or whispered speech—without using the larynx at all; so that in the use of the English language (at least) it may be said that the larynx is not an essential organ of speech. The function of the larynx is to give carrying power and inflexion to speech, and melody to song—it has nothing to do with the essential characteristics of speech.

If any one with a normal "ear for music" will whisper the words "Noah's rather at sea"—thinking of the sounds rather than of the sense—they will hear

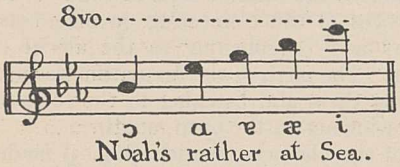


FIG. 1.

an ascending arpeggio something like the phrase shown in Fig. 1. The exact notes heard in each case will depend on *how* the individual person pronounces the vowel sounds in question.

These whispered or breathed notes are formed, as is well known, by the resonance of the cavity of the mouth, and they are varied for each different vowel sound by altering the size of the cavity and the opening of the mouth, mainly through the operation of the tongue and lips. With many of the vowel sounds, namely, **i** (eat), **ei** (hay), **e** (men), **æ** (hat), **o** (not), and in some types of **ɑ** (calm), two simultaneous resonant notes have been heard by many investigators, but the remaining principal vowel sounds, **ɔ** (all), **ou** (no), and **u** (who), have been generally supposed to be characterised by a single resonance.

Some observations made by me at the beginning of this year, using my own breathed vowel sounds, indicated that in *every* case the mouth—or rather the oral cavity as a whole, from the larynx to the lips—actually gives *two* simultaneous resonances for *each* vowel sound. It appeared that these pairs of resonant notes are not fixed in pitch for any one vowel sound, but might vary over three or four semitones—and sometimes even more—without a very appreciable change in the character of the vowel.

The resonances heard in the use of my own voice are set out in the accompanying chart, in which the vertical scale represents semitones of the equal temperament scale, and the vowel sounds are represented in the notation of the International Phonetic Association (Fig. 2).

It will be seen that **i** (eat), **I** (it), **ei** (hay), **e** (men), **æ** (hat), **ɐ** (earth), **ə** (sofa), **ʌ** (up), and **ɑ** (calm) form very nearly a converging series—the upper resonances falling by steps of 1 to 3 semitones, while the lower resonances are more active and take larger jumps—

[1] Substance of a lecture delivered at University College, University of London, on October 18.

not all in the same direction. From ɑ (calm) onward the resonances go down, as it were, hand-in-hand, keeping an equal distance of about 8 semitones apart; and it is possible, owing to this fact, that they have not been generally recognised as separate resonances.

The double resonance of the oral cavity when forming the vowel sound u (who) may be demonstrated by the clapping method (see NATURE, March 16, vol. 109, p. 341); also the possibility of varying both resonances independently at the same time. Similarly, the independence of the larynx note and the front resonance may be illustrated by simultaneously humming and whistling a convergent scale.

Having identified the various resonances on which

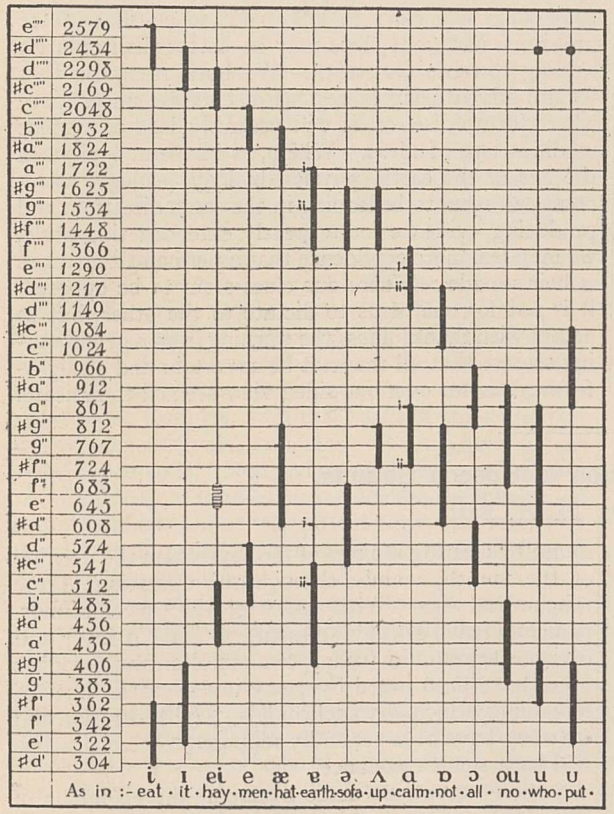


FIG. 2.—Vowel resonance chart. The horizontal dashes on the thick vertical lines denote the actual resonances of the models; the numerals i, ii denote successive models of the same vowel.

the production of the breathed vowels appeared to depend, the attempt was made to reproduce these vowel sounds by constructing some form of resonator which had resonances identical with those of the human mouth when a stream of air was blown through it. It seemed reasonable to expect that, if this could be done, the breathed vowel sounds would be reproduced. Models in plasticine were therefore made, the internal form of which very roughly imitated that of the human mouth and throat, except that the back portion corresponding to the pharynx was, for convenience, shortened and made more bulbous.

With this and similar models a number of experiments were made to test the effects of various alterations of the internal form—such as are actually made in the human mouth by the movement of the tongue, lips, etc.—and to discover the rules for tuning the instrument. An artificial larynx was made of a rubber strip lying across a flattened air passage—on the principle of the reed instrument which boys make with a blade of grass held between their two thumbs. When this reed or larynx was fitted to the back orifice of the model and blown, the model gave a voiced vowel.

The rules for tuning these models may be shortly summarised as follows: Enlarging the mouth generally raises both resonances. Increasing the projection of the lips or reducing the size of the mouth lowers both resonances. Raising the front of the tongue upwards or forwards raises the upper resonance but lowers the lower resonance. Pressing the back portion of the tongue backwards—so as to reduce the capacity of the back cavity corresponding to the human pharynx and to prolong the passage between the front and back cavities of the mouth—raises the lower resonance but lowers the upper resonance.

The experiments in tuning the plasticine cavities eventually made it clear that the human mouth, when making vowel sounds, always acts as *two separate "Helmholtz" resonators connected in series*—one behind the other—the back resonator being formed by the pharynx, the back of the tongue, and soft palate; the front resonator being formed by the front of the tongue, the hard palate, and lips; and the passage between the two resonators being formed by a hump in the middle of the tongue which approaches the roof of the mouth. By humping the tongue in different positions—forward or backward—the relative sizes of the front and back resonators can be altered at will, while the tuning can further be modified over a wide range by varying the opening of the mouth.

The resonant note of a cavity with an orifice to the open air depends, as is well known, on the relation between the volume of the cavity and the size of its orifices. The larger the cavity the lower the note; the larger the orifice the higher the note. With a resonant cavity having a neck—such as the neck of a bottle—the resonant pitch also depends on the length of the neck, being lower as the neck is made longer, and higher as the neck is shortened.

It follows from this that when two such resonant cavities are joined together, each one becomes, as it were, a neck to the other, and therefore influences its pitch. The effect is always to lower more or less the resonance of the neighbouring resonator according to the relation of the relative sizes of the two, and of the relative sizes of the connecting opening between the resonators and the opening to the air of the front resonator. The pitch of the resonators was ascertained by tapping them and listening to the resonant notes, or by blowing across the open mouth.

Each of the plasticine models (Fig. 3) made on this principle gives two resonances corresponding to a separate vowel sound. When the various models are blown in succession, first by mouth and afterwards for ɐ (earth) and ɔ (all) by bellows, the vowel characters are made more recognisable by covering and uncovering the mouth of the model by hand during blowing, so as to give an associated consonant (m or w). It was thus demonstrated that the vowel sound remains appreciably constant however much the pitch of the larynx note is altered by varying the air pressure.

Instead of putting the two resonators in series, as

already described, they may be placed in parallel—side by side—with a single larynx having a forked or bifurcated passage to communicate with each of them. Two models made on this principle—one tuned to give **i** (eat) ♯d''''2434 and f'342 and the other to give **ʌ** (up) g'''1534 and ♯g''812—when blown emit vowel sounds practically the same as those given by the corresponding resonators in series with a single mouth.

Certain vowel sounds can be produced by a single cylindrical or ovoid resonator. An egg-shaped plasticine resonator, when blown *through* by means of a small hole at the back, gave three resonances—c''512, g'''1534, and c''''2048, and a vowel sound intermediate between **e** (men) and **ɐ** (earth).

Double resonances may also be obtained from a cylindrical resonator closed at one end and blown through a small orifice in the closed end. A reed-actuated cylindrical resonator of variable length (lent by Prof. D. Jones) gave a series of vowel-like sounds, and a plasticine cylindrical resonator gave **ʌ** (up) with resonances ♯g'''1625 and ♯g''812.

These cases of double resonances produced by a single resonator are interesting as affording a possible explanation of Helmholtz's statement, that he had obtained certain vowel sounds by the use of a single resonator.

The reproduction of the various consonants appears to depend on exactly the same principles, namely, the combination of separate resonators (sometimes more than two), and it has been found possible to reproduce all the English consonant sounds also in this way. The principal difference is that, whereas with the vowels (other than the diphthongs) the resonances are more or less fixed during the voicing of each vowel, with most of the consonants the resonances are rapidly changing, and the consonant sound depends to a large extent on the rate of change.

To summarise these experiments and conclusions: We have seen that each of the English vowel sounds, when whispered or breathed, appears to consist of two musical notes due to the air current from the lungs blowing through the cavity of the mouth and throat. The cavity as a whole is divided up by the tongue into two resonating cavities—one behind the other—each of which produces its characteristic note.

When, instead of passing a steady current of breath through these resonators, we pass a current of air which has previously been set in vibration by the action of the larynx, the sound of the larynx note is coloured by the two resonators respectively and acquires the character which we recognise as voiced vowel sound.

The two resonances which characterise each of the different vowel sounds are not absolutely fixed in pitch for each vowel sound but may vary over several semitones; the tuning of the resonances is performed, in the mouth, mainly by the action of the tongue and lips, and is quite independent of the vibrations of the larynx.

In models, the double resonance of the human mouth can be reproduced by pairs of Helmholtz resonators joined together in series (making proper allowance for the reaction of each resonator on the resonating pitch one of the other) or by placing the resonators in parallel, side by side, so as to produce a double-mouthed model. When the resonators are driven tandem, the leader and wheeler may be counterchanged—so that, for example, the lower resonance is given by the front resonator instead of by the back, and *vice versa*.

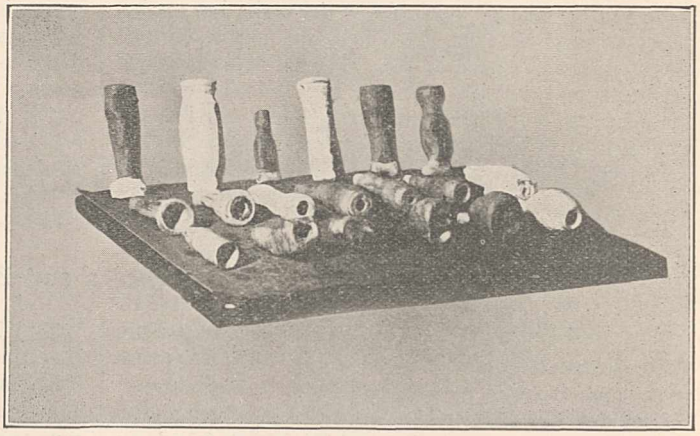


FIG. 3.—Plasticine resonators.

It follows that it should be possible to write down any vowel sound in musical notation, and to reproduce it by means of a suitable instrument designed to give any required pair of resonances, either in series or in parallel. It also follows that every one who can recognise vowel sounds must have a perfect ear for music, and an almost absolute sense of musical pitch.

Obituary.

C. L. WRAGGE.

BY the recent death of Mr. Clement L. Wragge, formerly head of the Weather Bureau at Brisbane, at Auckland, New Zealand, meteorology has lost an enthusiastic worker. Mr. Wragge was born at Stourbridge on September 18, 1852, and was educated at Uttoxeter Grammar School. After a short period of service in the Surveyor-General's department at Adelaide, he returned to England, where he founded several meteorological stations in North Staffordshire.

When the Scottish Meteorological Society wished to establish a meteorological observatory on Ben Nevis at 4400 feet above sea level, they were fortunate in securing the services of Mr. Wragge, who during the summers of 1881 and 1882 daily ascended the mountain and took regular observations. The Scottish Meteorological Society, in an appeal for public funds to found a permanent observatory on Ben Nevis, referred to "the observations made by Mr. Wragge with such skill, endurance, and enthusiasm during the last two summers on Ben Nevis." That very considerable endurance was

required for the work was graphically shown in an article in the *Times* for September 1, 1881.

Returning to Australia, Mr. Wragge served as Government Meteorologist for Queensland from 1887 to 1902, and he established the Weather Bureau at Brisbane, as well as high-level meteorological stations on Mount Wellington and Mount Kosciusko (7336 feet).

Mr. Wragge was an enthusiastic devotee of map meteorology, and in tracing the movements of cyclones and anticyclones he was accustomed to give these systems Christian names in his official reports. His views and methods, especially in later years, were frequently unorthodox.

DAVID LINDSAY.

ONE of the pioneer explorers of Australia has passed away recently at Port Darwin in the person of Mr. David Lindsay. Born in June 1856 at Goolwa, South Australia, of Scottish parents, Mr. Lindsay entered the State Survey Department as a youth, and in 1883 was selected to lead an expedition to Arnhem Land.

In 1888 Lindsay rode across the little known interior of the continent taking only a native boy as companion. His route took him to the Macdonnell Ranges, to which he returned shortly afterwards for more detailed examination. Mr. Lindsay's most fruitful expedition was in 1891, when he was chosen to lead the expedition equipped by Sir T. Elder for the exploration of the great Victoria desert of Western Australia. Using camels for transport, he crossed 550 miles of desert in 35 days and was able to amplify the work of E. Giles, who had crossed that district fifteen years previously. On his return Mr. Lindsay directed attention to the existence of large auriferous areas in the interior. The outcome of his report was the development of the West Australian goldfield, which he continued to explore for some years.

At a later date Mr. Lindsay returned to the examination of the Northern Territory and in 1913 was nominated to a Commonwealth Commission charged with considering the economic development of the north. In 1920 he reported the discovery of large tracts of well-watered land which had previously been regarded as desert, and he directed attention to the possibilities of cotton growing in the Northern Territory.

Current Topics and Events.

THE list of New Year honours includes the names of the following men distinguished by their scientific work or associations :—*Knights* : Prof. D. Drummond, Vice-Chancellor of the University of Durham ; Dr. W. H. Hamer, Medical Officer of Health for London ; and Dr. B. H. Spilsbury, hon. pathologist to the Home Office. *C.B.* : Dr. F. J. H. Coutts, Senior Medical Officer, Ministry of Health. *C.I.E.* : Dr. N. Annandale, director of the Zoological Survey of India ; Lieut.-Col. A. T. Gage, Indian Medical Service, superintendent of the Royal Botanic Garden, Calcutta, and director of the Botanical Survey of India, Bengal ; and Mr. F. A. Leete, Chief Conservator of Forests, Burma. *K.B.E.* : Prof. D. Orme Masson, F.R.S., professor of chemistry in the University of Melbourne. *C.B.E.* : Dr. J. W. Evans, F.R.S., a member of the governing body of the Imperial Mineral Resources Bureau ; and Mr. F. E. Smith, F.R.S., director of Scientific Research, Admiralty.

IT is gratifying to learn that Pasteur's centenary was celebrated at Lahore (India) on November 22 last, under the auspices of the Society for Promoting Scientific Knowledge. A conversazione was held at the rooms of the society and demonstrations given relating to Pasteur's researches. Great interest was taken by the public in the exhibits relating to crystals, silk-worms and their diseases, and microbes of various kinds shown under the microscopes. This was followed by a public meeting, at which Prof. B. L. Bhatia, president of the society, spoke on Pasteur's work in the biological field. Principal A. S. Hemmy, of the Government College, and Lieut.-Colonel C. A. Gill, of the K.E. Medical College, delivered speeches relating to Pasteur's work in the domains of chemistry and bacteriology respectively.

THE latest accounts of the Chilian earthquake of November 11 are mainly concerned with the destructiveness of the shock and accompanying sea-wave. The *Times* for December 28 contains the report of a correspondent who visited Copiapo and Vallenar five days after the earthquake. The meizoseismal area is sparsely populated, the towns within it containing only a few thousand inhabitants, most of whom dwelt in low adobe or wooden houses, and this no doubt accounts for the comparatively small loss of life. At Vallenar, which suffered most, there is not a house left standing that is fit to live in, yet, out of a population of 5500, not more than 600 persons were killed and a thousand injured. Interesting photographs, showing the completeness of the destruction by the sea-waves at Coquimbo and Chañaral, are reproduced in the *Times* for December 19 and 28.

AT the meeting of the London Mathematical Society on January 18 at 5 o'clock, in the rooms of the Royal Astronomical Society, Burlington House, Mr. L. J. Mordell, reader in pure mathematics in the University of Manchester, will lecture on "An Introductory Account of the Arithmetical Theory of Algebraic Numbers, and its Recent Developments." Members of other societies, or any one who wishes to learn something concerning the theory of ideal numbers, will be welcomed.

A TRIBUNAL of investigation into the agricultural problem has been appointed as follows : Sir William Ashley, professor of commerce and vice-principal of the University of Birmingham ; Prof. W. G. S. Adams, Gladstone professor of political theory and institutions, Oxford ; and Prof. D. H. MacGregor, Drummond professor of political economy, Oxford.

Mr. C. S. Orwin, director of the Institute for Research in Agricultural Economics at Oxford, has been appointed agricultural assessor to the tribunal, and Mr. D. B. Toye, of the Ministry of Agriculture and Fisheries, will act as secretary.

IT is announced that Messrs. Ashton and Parsons, Limited, have made to Guy's Hospital the generous gift of 2600*l.*, to be paid in six and a half yearly instalments of 400*l.* each. This money is to be spent in research on diabetes and related metabolic disorders, and to be called a Parsons fellowship. At the present time, much work is required in investigating the properties and methods of preparation of extracts of the pancreas, one of which is known as "insulin." This endowment will assist to a notable degree the work already for some time in progress at Guy's Hospital in connexion with the pathology of diabetes.

PROF. W. M. FLINDERS PETRIE has consented to give a lecture on "Royal Burials in Egypt," with special reference to recent excavations in Egypt, on Tuesday, January 23, at 5.30, in University College, London. The lecture will be illustrated by lantern slides, and the proceeds will be given to the St. Christopher's Working Boys' Club, which is connected with the Union Society and Women's Union Society of the College. A leaflet containing full particulars as to the prices of the tickets can be obtained by sending a stamped addressed envelope to Dr. Walter Seton, University College, Gower Street, W.C.1.

THE Council of the Royal Statistical Society will, in November next, award the Frances Wood Memorial Prize, value 30*l.*, for the best investigation of any problem dealing with the economic or social conditions of the wage-earning classes, the subject to be chosen by the competitor and treated on statistical lines. Competing essays (which must be either printed or typed, and accompanied by copies of all statistical tabulations), must be sent to the Honorary Secretaries of the Royal Statistical Society, 9 Adelphi Terrace, W.C.2, not later than July 1, 1923.

THE *Times* reports that a wireless message has been received *via* the radio station at Spitsbergen from Capt. Wisting, of Amundsen's Norwegian North Polar expedition. The *Maud*, which left Cape Hope, Alaska, on July 26 for her drift across the polar basin, met pack ice in about lat. 70° N. Pushing through the ice the ship was near Herald Island on August 7, and on August 22 was frozen into the pack in lat. 70° 20′ (? 72° 20′) N., long. 175° 25′ W. The drift first carried the vessel back to lat. 72° N. and then to lat. 73° N., and finally due west. On December 15, when the message was despatched, the *Maud* was in lat. 73° 20′ N., long. 173° W. (? E.). On September 26 the *Maud* was exposed to heavy pressure but rose uninjured, the ice meeting below her. The message reports that fine weather has been experienced and that scientific work is proceeding satisfactorily. Contrary to expectation, animal life is scanty, but a few seals and two bears have been secured. This is the first message beyond two brief weather reports that has been received since the *Maud* left Alaska. Capt. Amundsen is wintering in Alaska ready to attempt his flight to Spitsbergen next summer.

THE Research Medal of the Worshipful Company of Dyers has recently been awarded to Prof. G. T. Morgan for a dissertation on the co-ordination theory of valency in relation to adjective dyeing. This comprehensive theory of chemical affinity, propounded originally by A. Werner of Zürich, offers a means of correlating many of the facts observed in the dyeing of textile fibres with mordant or adjective colouring matters. The tinctorial effects produced are due to the formation within the fibres of insoluble coloured salts or lakes which in general are characterised by the following properties: sparing solubility in aqueous solutions, exceptional shade and fastness of colours, resistance to chemical reagents, and an inhibition of the ordinary analytical reactions of the metallic bases implicated in the lake complex. By the use of a cobaltammine reagent, Drs. Morgan and Main Smith have shown that in three series of adjective dyes—the quinoneoxime dyes, the alizarin series, and the azosalicylic acid dyes—the formation of a complex lake is due to the presence in the adjective colouring matter of a characteristic radical—the so-called "chelate" group—which has the distinctive property of satisfying completely the chemical affinity of the metallic component of the lake. These researches are being extended to other natural and synthetic adjective colouring matters.

AT the end of the recent gliding week on the South Downs, the German duration records were broken by a Frenchman, M. Alex. Maneyrol, who stayed in the air 3 h. 22 m. The machine used in this feat was a Peyret Tandem Monoplane, and it was remarked at the time that this machine recalled the form of aeroplane constructed by S. P. Langley many years back. In a note issued by the Smithsonian Institution on November 28, 1922, reference is made to this vindication of Langley's design of a flying machine, and a short account is given of the history of the researches conducted by Langley. He began in 1887, and by 1892 had evolved a small "aerodrome" model. In May 1896 a model flew for 1½ minutes (a photograph of this flight accompanies the note). Work on a full-sized machine began in 1898, and was supported by the War Department, Board of Ordnance and Fortification, U.S.A. A machine was ready in 1903, but the trials were unsuccessful and hostile press criticism caused the withdrawal of official support. Langley died in 1906. It is claimed that the original machine, "overhauled but not materially changed," flew in 1914, and that "these flights proved conclusively the fact that Prof. Langley developed and built the first man-carrying aeroplane capable of sustained free flight." No reference is made to the recent controversy on this question of priority.

MAJ. W. F. BLAKE gives in *Discovery* for January a full account of the attempt to fly round the world made by Capt. N. Macmillan, Mr. G. Malins, and himself. Beginning their journey on May 24, 1922, his

party crossed to Marseilles, thence *via* Athens, Aboukir, Bagdad, Bandar Abbas, Quetta, Lahore, Agra, Cawnpore, reaching Calcutta on August 12. The passage over India was impeded by an unusually heavy monsoon. At Agra, Maj. Blake was struck down by appendicitis, and the other two members of the party on route to Rangoon were forced to descend in the Bay of Bengal, where they were fortunately rescued by Lieut.-Commander Canning, who had been sent from Chittagong to search for them. Maj. Blake, with the experience gained from their adventure, hopes to make a further attempt in 1923.

THE inaugural meeting of the Far Eastern Association of Tropical Medicine was held in Manila in 1908; it was followed in 1910 by the first congress at the same place. Subsequent meetings were held in Hong-kong, 1912, and Saigon, 1913. The fourth congress was held at Weltevreden, Java, in August 1921, and a proposal made on behalf of the Governments of the Straits Settlements and Federated Malay States, that the next congress of the association, in 1923, be held in Malaya, was accepted. Dr. A. E. Horn was chosen president for the forthcoming session; Drs. A. L. Hoops and R. Dowden were elected vice-presidents for the Straits Settlements and Federated Malay States respectively, and Dr. J. W. Scharff as honorary secretary for Malaya. The association, which is open to all recognised medical men, exists to promote the science and art of tropical medicine in the Far East. To this end, it provides opportunities for intercourse among medical men and endeavours to assist in the enlightenment of public opinion on problems of hygiene and particularly of the prevention of disease among the natives. The forthcoming meeting will be held on September 3-17, 1923. The first week of this period will be devoted to scientific discussions, and the following week to excursions to places of medical and sanitary interest throughout Malaya. The Governments of the Straits Settlements and Federated Malay States, recognising the important functions of this association, are contributing a considerable sum towards the expenses.

THE report of the eleventh ordinary meeting of the International Meteorological Committee, held in London, 1921, has recently been published by the Meteorological Office of the Air Ministry. It contains details of the several meetings of the committee and of the commissions for weather telegraphy, marine meteorology, aerial navigation, *réseau mondial*, and polar meteorology. A general account of the work of the International Meteorological Committee has already been published in NATURE (October 6, 1921, p. 194) shortly after the close of the eleventh ordinary meeting held in London in September 1921. The present report occupies 128 pages, more than one half of which consists of appendices giving detailed information of the several commissions held for reporting to the general meeting. Among the details of interest may be mentioned the recommendation that the meteorological stations in high latitudes, commenced in connexion with Amundsen's polar expedition, be continued during 1921 to 1925, and if possible permanently. Other points discussed are the unification of upper air data so that it might be possible to publish, within a few hours of the observations, a chart of upper air observations for the whole of Europe; the study of clouds from the point of view of aviation and the general application of meteorology to aerial navigation; and an endeavour to systematise the adoption of the "kilometre per hour" as the unit of wind velocity by all countries both for land and air. An effort was also made to standardise instruments for registering sunshine.

THE annual report of the Raffles Museum and Library, Singapore, for 1921 shows that, under the energetic direction of Major J. C. Moulton, these institutions make good progress. The number of outside helpers in Singapore and other parts of the world on whose services the museum can draw is a good sign. The formation of a Singapore Natural History Society, with headquarters at the museum, is recorded. Out of 240,000 visitors of various nationalities, 165,000 were Chinese.

MR. BAILEY WILLIS, in a popular paper on "The Geology of the Colorado River Basin with reference to Engineering Problems" (*Science*, August 18, 1922), discusses the boulder-bed in the floor of the Colorado cañon, and the difficulties of building a concrete dam on such a foundation. Work can be carried on between flood-times only, and hence it has been boldly suggested that, since the floods can shift the boulders, more boulders shall be quarried out of the jointed granite and given as playthings to the floods. The river is to be encouraged to construct its own dam to the satisfaction of the engineers who seek to utilise its power.

A WELCOME second edition has made its appearance of the admirable "Guide to the Elephants (Recent and Fossil) exhibited in the Department of Geology and Palæontology in the British Museum (Natural History)." As before, its preparation is the work of Dr. C. W. Andrews, whose name is sufficient guarantee of its excellence. It is slightly increased, as compared with the first edition, by additions to the text, chiefly in the opening paragraphs, and by a new figure. There are also numerous minor emendations, while useful sub-headings have been inserted. Economy has been appeased by issuing the pamphlet in paper covers instead of paper boards.

WE have received a copy of the third volume of Messrs. Baird and Tatlock's Standard Catalogue of Scientific Apparatus. This covers the more specialised apparatus useful in the biological sciences—anatomy, botany, zoology, pathology, agriculture, etc.—though physiology and biochemistry are dealt with in volume 2. The abundant illustrations make it a convenient and useful guide to most of the apparatus which is available, and in turning over the pages a scientific worker may get useful hints towards solving special problems of technique familiar in some department other than his own. Such catalogues do something at any rate towards bringing the different branches of biological inquiry together as well as in facilitating the daily work of the laboratory.

Our Astronomical Column.

NEW OBSERVATIONS OF JUPITER. — Mr. W. F. Denning informs us that Mr. Frank Sargent, of the University Observatory, Durham, observed Jupiter on the morning of December 24, and saw the hollow in which the great red spot is situated central at 19h. 13m. G.M.T., which corresponds to a longitude of 239°·6. Mr. Sargent considered this hollow in the great southern belt decidedly more shallow than formerly. The great red spot appeared to be shorter than at the last opposition, its length being estimated as only 22 degrees.

Following closely behind was the preceding end of the south tropical disturbance which made its transit at 20h. G.M.T. in longitude 268°. The rotation periods of these two objects during the last six months were:

Red Spot Hollow = 9h. 55m. 38s·1.
S. Tropical Disturbance = 9h. 55m. 29s·8.

These periods correspond very nearly with those derived during the earlier part of the year 1922.

BAADE'S COMET.—This comet was observed by Dr. W. H. Steavenson on December 20 and 22. He describes it as follows: "Magnitude 9 to 10, small, compact; diameter about 1′; best defined in position angle 165°, rather diffuse towards 345°; there was central condensation, but no well-defined nucleus."

The brightness is only falling off slowly, and the comet is still within reach of moderate instruments. The following ephemeris, by Mr. Johannsen, of Copenhagen, is very accurate. It is for Greenwich midnight:

	R.A.			N. Decl.
	h.	m.	s.	
Jan. 5.	22	55	22	19° 16′
,, 9.	23	4	30	18 46
,, 13.	23	13	30	18 18
,, 17.	23	22	22	17 54
,, 21.	23	31	6	17 31
,, 25.	23	39	43	17 11

The comet is crossing the lower portion of the square of Pegasus. It is desirable that observations should be continued as long as possible, in order to detect any deviation from parabolic motion.

BRITISH ASTRONOMICAL ASSOCIATION HANDBOOK FOR 1923.—Two years ago, when the well-known "Companion to the Observatory" was discontinued, the Council of the British Astronomical Association decided to bring out the Handbook to take its place (London: Eyre and Spottiswoode, Ltd. Price 2s. to non-members.) Its aim is to supplement, not to supersede the Nautical Almanac, from which little is reprinted except the physical ephemerides. The periods of visibility of the planets are shown graphically; details of important occultations, including four of Aldebaran, are given for 12 stations. Ephemerides are given for Vesta, Eros, and D'Arrest's Comet; it is hoped to extend this section further in future. The large-scale diagrams of the small stars near Uranus and Neptune will be useful for observers of these planets. Notes are included on telescopic objects, lists of tests, ephemerides of variables, and in particular the dates of maxima of 27 stars that attain naked-eye visibility. There are also definitions and an extended list of astronomical constants and elements, which will be slightly varied from year to year. There are thus few observers who will not find the book useful in their domes.

ATMOSPHERIC DISPERSION IN PARALLAX WORK.—One of the factors in the great improvement that has been effected in the photographic determination of stellar parallax has been the recognition that work must be limited to the neighbourhood of the meridian, where the effect of atmospheric dispersion is small. Messrs W. M. H. Greaves and C. Davidson have investigated the resulting correction to the parallax for stars of extreme spectral type in a paper read at R.A.S. November meeting. At 20 minutes of time from the meridian the correction for type B_0 is $-0''{\cdot}009$, and for type M $+0''{\cdot}005$. These are quantities that cannot be neglected nowadays, so the necessity is emphasised for working still closer to the meridian where possible.

The same difficulty is present in obtaining the solar parallax from photographs of Eros or other small planets, especially since the diurnal method necessarily involves considerable hour angles. The error can be diminished by using a visual refractor with a light filter, if the object is bright enough to permit of this.

INTERFEROMETER MEASURES OF DOUBLE STARS.—The *Astrophysical Journal* for July has a paper by Mr. Paul W. Merrill on this subject. Mr. Merrill continued the observations of Capella with the 100-in. telescope at Mt. Wilson, and gives the following orbit from his own and Anderson's measures: Period 104·022 days, $a = 0''{\cdot}0536$, distance = 126,630,000 km., parallax $= 0''{\cdot}0632$, masses 4·2 and 3·3 in terms of sun. He finds that the Greenwich measures in 1900 (on which considerable doubt has been cast) are fairly well represented on the supposition of a motion of the node of 0°·9 per annum; this motion is suggested by the interferometer measures themselves.

The duplicity of κ Ursæ Majoris was independently detected with the interferometer. The magnitude difference is much greater than in Capella, but does not exceed half a magnitude. When Aitken discovered its duplicity in 1907-8, the position-angle and distance were 283°·2, 0″·21; they are now 251°·3, 0″·08.

υ^2 Bootis was also examined, but the results were more doubtful; the method is obviously a very powerful one in cases where the magnitudes are not too unequal.

SOLAR PROMINENCE ACTIVITY.—Every half-year the Kodaikanal Observatory, India, issues a bulletin giving a summary of prominence observations during that period. The data for the first half of the present year in Bulletin No. lxx. have just been received. The mean daily areas and daily numbers of the prominences are few, as was to be expected from the cyclical nature of the phenomena, the respective figures being 3·17 (square minutes) and 11·05. Their distribution in latitude shows maxima in the belt 45°-50° in both hemispheres, and is very similar to that for the previous half-year; this indicates that a new cycle of activity has begun in the higher zones of prominences. The statistics give further the distribution of prominences east and west of the sun's axis, the activity of the metallic prominences, particulars of the displacements of lines observed in the spectra of the chromosphere and prominences, reversals and displacements of $H\alpha$ and D_3, and finally, areas and numbers of prominences projected on the disc as absorption markings. These valuable data are of great importance because they provide a complete record of the activity of the sun from a prominence point of view on a homogeneous system.

Research Items.

SUICIDE RATES.—The relation of suicide to climatic and racial factors, and to industrialism, occupation, urban conditions, age, and sex, etc., is the subject of an extensive statistical analysis by Dr. J. R. Miner (*American Journal of Hygiene*, Monographic Series, No. 2). It has long been recognised that the suicide rate is higher among the Nordic race than among Alpine or Mediterranean peoples. Mixed peoples usually have a higher rate than either of the pure races to which they belong. Foreigners in New York show a higher suicide rate than in the countries from which they came. The lowest rate is found in Ireland and the highest in Saxony, while the rate varies in different parts of France according to the racial composition of the population. Among Asiatic peoples, the Japanese and Chinese rates are high, while in India it is low (4·8 per 100,000). India appears to be the only country where female suicides exceed the male. The general trend of suicide rates has been upward during the last century, but the higher rates tend to become stabilised. A sharp decline took place during the war. Germany, France, Denmark and Sweden have high rates, Britain, Norway and the Netherlands low rates, as well as southern and eastern Europe. In the United States the rates are lowest in the south and highest in the west. The fundamental causes of these differences are found to be probably in (1) differences in the strength of the group spirit, (2) adverse economic conditions, (3) racial factors, (4) general health of the population.

REPRODUCTION IN THE LEODICIDÆ.—Prof. A. L. Treadwell's memoir on the Leodicidæ (Eunicidæ) of the West Indian Region (Dept. Marine Biol. Carnegie Instn., Washington, 131 pp., 9 pls., 467 text figs., 1921) gives a full systematic account and records in the text and in the coloured plates the character of the living coloration. Included in this family is *Leodice* (*Eunice*) *fucata*, which lives in crevices of the coral rocks, protruding the anterior end for feeding but not exposing the remainder of the body except at the breeding season. On the approach of the breeding season the body becomes much distended with eggs or with sperms and swarming occurs usually in coincidence with the last quarter of the June-July moon. During the night the worms protrude their posterior ends from the rocks and break them off at the junction between the sexual and non-sexual portion. The sexual portion swims to the surface and is found in large numbers on the surface at daybreak. Just at sunrise the thin body-wall bursts, the eggs and sperms are liberated, and fertilisation of the eggs occurs. Prof. Treadwell showed in 1914 that there is a measurable increase in the output of carbon dioxide by the egg as it approaches maturity, and he suggests that increased elimination of waste products into the body cavity of the worm may act as a stimulus to egg-laying.

DIGESTION OF WOOD BY THE SHIPWORM.—Dr. P. Bartsch's monograph of the American Shipworms (Bull. 122, U.S. Nat. Mus., 1922, 51 pp., 37 pls.) is restricted to the systematic aspect. He recognises in the family Teredidæ three genera—Bankia, divided into four sub-genera, with eight species; Bactronophorus, not yet reported in American waters; and Teredo, divided into seven sub-genera, with twenty-one species. Systematic descriptions of and keys to the species are given. Dr. Bartsch remarks that although the shipworm takes wood resulting from its boring operations into its alimentary canal, it is questionable whether the secretions of the digestive glands are capable of producing from the wood any soluble carbohydrate. Harington (*Biochem. Journ.* xv., 1921, pp. 736-741) investigated this point more than a year ago and, though he was not able to reach a definite conclusion, the balance of evidence was in favour of the view that Teredo has in its liver an enzyme capable of producing glucose from some constituent of wood, and hence it may be supposed that the wood is to some extent made use of as a source of nourishment.

AMERICAN MYCOLOGY.—The first part of volume 9 of the Annals of the Missouri Botanical Garden (February 1922) is completely filled with a revision by Prof. E. A. Burt of the North American species of Clavaria. This study will be of great value to American students of this group of fungi, and British mycologists will note with satisfaction that full use is made of the valuable study of the British species by Cotton and Wakefield in the Transactions of the British Mycological Society (1919). The author's discussion shows that plenty of work remains to be done by American mycologists, but probably this work with its full reference to American type specimens will provide the necessary stimulus as well as the basis from which to start. The illustrations, photographs of dried herbarium specimens, seem scarcely suitable for a work of this systematic character. In some cases, recognition may be facilitated by the photograph, in others it may well be misleading to unexperienced mycologists. Figures 90, 91, 92, and 94 might very well have been obtained from a single gathering of any one of the four species illustrated.

WET BULB TEMPERATURES AND THERMODYNAMICS.—In the memoirs of the Indian Meteorological Department, vol. xxiii. part 1, Dr. C. W. B. Normand, Imperial Meteorologist, discusses wet bulb temperatures and the thermodynamics of the air. In India in recent years the daily values and the monthly means of wet bulb temperatures have been published, since medical officers pay more attention to the wet than to the dry bulb readings, especially as to conditions liable to cause heat strokes. The aim of the paper is to create further interest in the actual wet bulb temperatures. Mathematical considerations are freely introduced, and the discussion opens up the subject to wider considerations. At the fortnightly meeting held at the Meteorological Office on October 30, the paper by Dr. Normand was taken for discussion, and the subject was opened by the author, who is now in England. A summary of the discussion at the Meteorological Office is given in the *Meteorological Magazine* for November. It was brought out that the term "wet bulb temperature" in the paper is ambiguous, and it was suggested that it seems better to use the term "adiabatic saturation temperature."

METEOROLOGY IN INDIA.—A report on the administration of the Meteorological Department of the Government of India in 1921–22 has just been received. It is drawn up by Dr. Gilbert T. Walker, Director-General of Observatories to the Indian Government. After special investigation Stevenson's thermometer screens, commonly used in Great Britain, are to replace the large open-sided shade hitherto used in India for the exposure of thermometers. This will bring India into line with our home observations, and will effect a very great saving of expense when new screens are required. The English screen

is only about one-sixteenth of the price of the Indian screen hitherto used. Much valuable data on the upper wind currents have been recently published and other upper air data are ready for publication. Considerable demand is being made for upper air results over India and the report regrets the inability to do all that is required for want of funds. In the British Isles the staff of workers has been immensely increased and without doubt considerable increase of the staff in India will have to be faced, although it will mean added expense. A graph showing the growth in activity and cost for the last 15 years is given at the end of the report. For want of funds much useful work has been discontinued. The stations over India from which detailed observations are received now number 281, and these have to be supplied with instruments and inspected periodically. Observations are secured from vessels by wireless, as well as from the ordinary logs, over the neighbouring seas. Seismological observations are recorded at several stations and the data are supplied to the British Association. For rainfall over India, there are now 2928 stations from which observations are received.

THE NEW FLIGHT COMPASS.—The United States Air Service has set itself the task of putting the navigation of the air on as trustworthy a basis as that of water, and as part of its programme has asked the Bureau of Standards to investigate the possibilities of the earth inductor type of compass. As a result, a form of instrument has been devised which has proved more satisfactory than any previously in use in the Air Service. A memoir describing the instrument was presented in 1921 to the American Philosophical Society by Messrs. P. R. Heyl and L. J. Briggs, and was awarded the Magellanic premium. It is now reproduced in part 1 of volume 41 of the Proceedings of the Society. An armature driven about a vertical axis by a cup propeller has four carbon brushes set at right angles to each other in contact with its commutator, and capable of being set so that when the aeroplane is flying in a fixed direction, one pair of brushes gives a maximum and the other pair zero electromotive force. The two pairs of brushes are connected to four equally spaced points of a closed electric circuit and a pointer galvanometer connected to two points opposite each other on the circuit. The diameter for which the galvanometer gives zero deflection is determined by the course of the aeroplane.

BURNING HEAVY FUEL-OIL.—Some of the technical difficulties encountered in burning heavy fuel-oil in Diesel engines and other types of heavy-oil engines were discussed by Mr. Harold Moore in a paper read by him at the North-East Coast Institution of Engineers and Shipbuilders, Newcastle, early in December. Ignition trouble, difficulties in burning oil after ignition has taken place, and the problems raised by the presence of small quantities of impurities, were the main factors dealt with as affecting the utilisation of heavy fuel. With regard to ignition trouble, a great deal depends on the range of ignition temperatures possible with varying types of oil-fuel; in Diesel and cold-starting engines, ignition takes place when the heat of compression exceeds the spontaneous ignition temperature of the oil, and it is customary to adjust the compression so as to ensure regular ignition of whatever class of fuel is burnt. The utilisation of various petroleum and coal-tar oils necessitates repeated adjustments being made, and these, under changing conditions of low and high load running, atmosphere, etc., have to be considered carefully both theoretically and practically. Pilot ignition gears, which to a large extent overcome initial difficulties of firing, are now installed on most Diesel and cold-starting engines. After ignition has taken place, the smooth burning of the oil depends primarily on its complete combustion before the exhaust valve opens, and on the rate of burning and influence of the various substances in the fuel. Such substances include the bituminous bodies present in petroleum, hard and soft asphaltum, waxes, and in the case of coal-tar oils (more often employed on the continent than in this country), naphthalene and anthracine. Finally the effects of water, sand, and iron rust, the commonest impurities in oil-fuel, constitute not unimportant factors to be reckoned with. Such impurities are best removed by the employment of high-speed centrifuges.

MAGNETIC OBSERVATIONS AT BATAVIA.—Volume 40 of the Observations made at the Royal Magnetical and Meteorological Observatory at Batavia contains the observations of the year 1917. The preface, however, brings the history of the observatory down to February 1922. From it we learn of the retirement of the well-known director, Dr. W. van Bemmelen, who has been succeeded by Dr. Braak. In addition to the usual meteorological tables, the publication contains some special results of interest, including the results of a 7-year comparison of ordinary thermometers in the thermometer shed and ventilated Assmann thermometers outside. The differences are substantial. The magnetic results are very complete, two magnetographs being in constant operation. The tables of hourly values refer to three rectangular components of force, the horizontal components being in and perpendicular to the astronomical meridian, which is there nearly coincident with the magnetic. An interesting chart shows the departures of the three rectangular components from their mean yearly values. These departures are calculated for 1 h., 7 h., 13 h., and 19 h. G.M.T. of every day, the value assigned to each hour being a mean from 24 hours centering at that hour. The great predominance of disturbance in the north-south component is effectively shown.

PHOTOGRAPHIC SENSITISERS AND DESENSITISERS.—Prof. Rudolfo Namias describes some of his remarkable experiences with these reagents in "The Process Year-Book," vol. xxv., 1923. He agrees with Dr. Luppo Cramer that pinaflavol, the most recently introduced colour sensitiser, is unique in its property of sensitising for the well-known gap in the greenish-blue, and that it and pinacyanol give a "very high increase of general sensitiveness." He finds that pinacyanol may be used in a solution fifty times diluted as compared with the concentration generally advised (finally equal to one part of solid in five millions) and that the spectrographic tests show that this enormous dilution makes no difference in its effect. He has discovered that desensitisers are more important than they were at first thought to be. By getting rid of the sensitiveness of the plate they avoid the formation of the development fog always produced when development is continued to bring out the weak detail which, however, is generally buried by it. By making this detail available we get a practical increase of sensitiveness, though the advantage is restricted, so far as is known, to the use of safranine, and of hydroquinone and alkaline bromide in the developer. The increase of general sensitiveness and the elimination of development fog enable one to use slow plates with their much finer grain, and so, without the practical sacrifice of sensitiveness, to get a considerable gain in resolving power.

The Wegener Hypothesis.

DISCUSSION AT THE BRITISH ASSOCIATION, HULL.

ON Monday, September 11, the meeting room of the Geological Section of the British Association was the theatre of a lively but inconclusive discussion on the Wegener hypothesis of the origin of the continents. This hypothesis, which is a development of the well-established theory of isostasy, regards the continental masses as cakes of light siliceous material floating on a heavier basaltic, fluid or viscid, substratum, which in its turn reaches the surface in a solidified form on the floors of the oceans. The continents, which are thus movable, are supposed in Carboniferous times to have formed a single mass, and to have split up by rift-valley formation and started floating apart in late Cretaceous or early Tertiary times. The mountain ranges fringing the Pacific are supposed to have been produced along those margins of the continents which are or have been, in virtue of their motion, impinging on the hard oceanic crust, the belts of thick sedimentation along the continental shelves localising the folding.

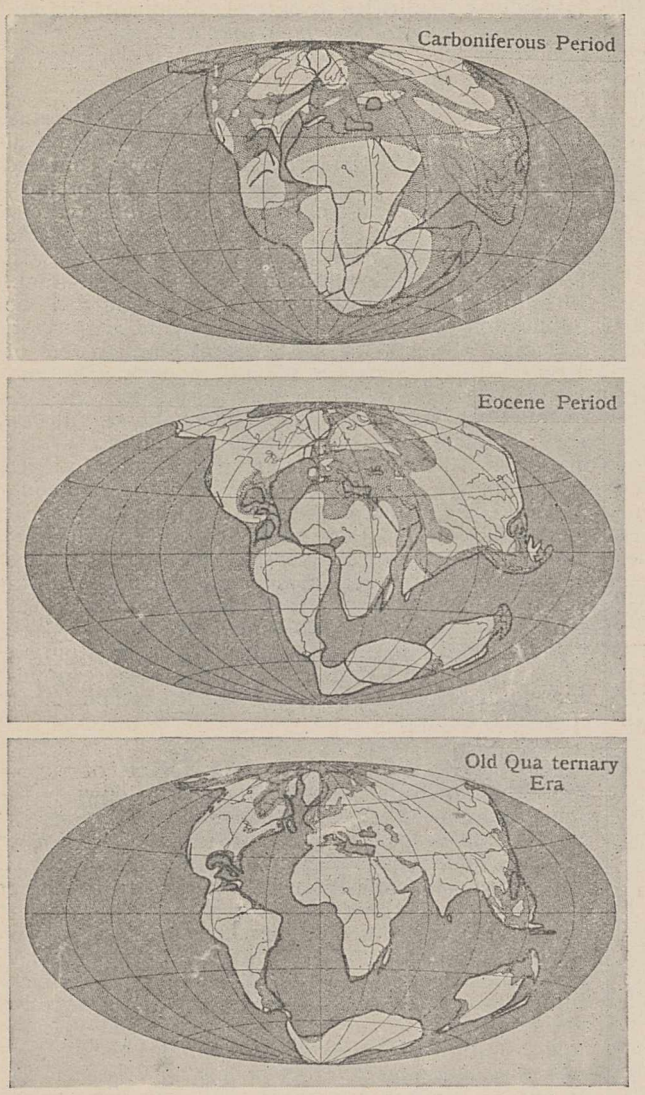


FIG. 1.—The world in the Carboniferous and Eocene periods and Old Quaternary era according to the displacement theory. White denotes land, dots shallow water, cross-hatching deep sea. From *Discovery*, May 1922, p. 116, by the courtesy of the publishers.

The union of the continental masses in former geological times explains many peculiarities in the distribution of life both past and present. It also affords an easy explanation of the hitherto unsolved problem of the Permo-Carboniferous glaciation, by supposing the pole to have been located in South Africa and the other glaciated parts of Gondwanaland to have been grouped around. When a reconstruction of this sort is made it is found that the main Carboniferous coalfields of the world lay, at the time of their formation, within the tropics.

The discussion brought forth a great diversity of opinion regarding the validity of the hypothesis, almost the only point on which there seemed to be any general agreement being an unwillingness to admit that the birth of the North Atlantic could have occurred at so late a date as the Quaternary. Proceedings were opened by the reading of a discourse by Dr. J. W. Evans, who was unfortunately unable to be present. Dr. Evans gave an outline of some of the leading features of the theory and emphasised the well-known similarity of the geological formations on opposite sides of the oceans. He, however, questioned Dr. Wegener's estimates of the thickness of the crust whether continental or oceanic, and considered that the latter, being probably as strong as the continental crust, would inhibit the continental drift. He dealt more particularly with the supposed recent variations of relative longitude and with the precautions which would have to be taken in the case of an attempt to repeat the observations.

Prof. H. H. Turner stated that the only piece of astronomical evidence supporting Wegener's hypothesis, and worthy of serious consideration, was the apparent westerly drift of Greenland. He was inclined to regard the longitude observations made up to the present as so much waste paper, but considered that the magnitude of the discrepancies between the Greenland observations of the years 1870 and 1907, which indicated a westerly drift relatively to Europe of 1200 metres, made a good case for repeating the observations to-day.

Mr. W. B. Wright pointed out that a critical comparison of the geological formations on the two sides of the North Atlantic shows on the whole a very remarkable correspondence, both stratigraphical and palæontological, from the Archæan to the Cretaceous, and in particular brings to light certain facts even more strikingly indicative of a former *rapprochement* between the two continents than any pointed out by Wegener.

The recurrence in America on opposite sides of the old Appalachia of the two facies of the European Cambrian and early Ordovician, which are here separated by the Caledonian chain, is perhaps the most striking, the lithological and faunal characters and the sequence of transgression and recession, different on either side of the chain, being reproduced with remarkable precision. Again, the continental and marine facies of the Devonian are separated in both countries by boundaries which become conterminous on the Wegener reconstruction.

Prof. Coleman, of Toronto, considered that the similarity in the Archæan formations on the two sides of the Atlantic, cited by Mr. Wright, meant very little, as the Archæan was a universal formation. He also raised the question of the meteorological

conditions of the supposed compacted continent of Gondwanaland, which he thought must necessarily have been a desert and therefore could not have nourished an ice sheet.

Prof. Sollas confessed himself attracted by the theory but doubtful as to proofs. He was not greatly impressed by arguments based on the similarity of the geological formations on the opposite sides of the oceans, the most remarkable of which was perhaps that cited by Mr. Wright. A certain uniformity is to be expected in rocks derived from the same Archæan base. The explanation on the whole was out of proportion to the points of correspondence cited.

Dr. Harold Jeffreys stated that the rotational force which could be invoked to explain the movements of the continents was very small and quite insufficient to produce the crumpling up of the Pacific ranges. The ocean floors also presented a difficulty, for, being composed of basaltic rock, they would be less radioactive and therefore stronger than the continental crust. The withdrawal of India northward and its gathering up into the Himalayan folds were moreover not easily accounted for.

Prof. Gilligan said that, as the great piles of Palæozoic sediments in Europe and America reached their maximum thickness on the borders of the Atlantic, it seemed necessary to assume the presence of a continent occupying the northern part of the ocean. The time-honoured conception that the earth shows a tendency towards a tetrahedral form was also in conflict with this new hypothesis.

Dr. G. C. Simpson thought the theory was a wonderful one from the meteorological point of view, as it explained the marked changes of climate given by the geological record and in particular the excentric position of the Quaternary ice-sheets with reference to the pole.

Prof. Marshall, of Wanganui, New Zealand, pointed out that the movement of that country was to the east and not to the west. Speaking from personal knowledge of a number of the Pacific Islands and referring to the evidence they afforded as to the composition of the floor of the ocean, he said it was a mistake to suppose that the igneous rocks exposed in these islands were entirely basaltic. Alkaline rocks were also represented, but, so far as he was aware, siliceous rocks of continental type were unknown.

Dr. F. E. Wright spoke briefly, and Prof. Boswell referred to the forthcoming English edition of Dr. Wegener's book as affording an easy means of becoming acquainted with the leading features of the subject.

The president, Prof. Kendall, in closing the discussion said he had many years ago examined the question of a land connexion across the Atlantic, especially in its bearing upon the distribution of fishes and reptiles. The practical identity of the Old Red fish faunas of the Orkneys and N. America seemed to show a very close connexion, and the similarity extends to the Carboniferous. Divergence, especially in the reptiles, is marked in the Trias and probably complete throughout the Jurassic. Unfortunately the reptiles require two barriers, one of land to stop the migration of the marine forms, and one of sea to inhibit that of the land forms. The evidence adduced by Martin Duncan and marshalled by Gregory proved a connexion between Europe and America during the Oligocene. He had long ago found it necessary to abandon a belief in the absolute permanence of ocean-basins.

The discussion as a whole was interesting as bringing out the extreme divergences of opinion produced by viewing the hypothesis from different aspects, astronomical, physical, meteorological, and biological, but it becomes very apparent that the surest test of its validity lies in the domain of geology.

W. B. WRIGHT.

The National Research Council of America.

THE National Research Council of the United States corresponds to the Department of Scientific and Industrial Research in this country. It owes its being, as does our organisation, to the very urgent need, which the war made patent to governments, of an organised and systematic attempt to foster scientific research, to extend its industrial applications and, by co-operation and co-ordination, to do this on a national scale. The sixth annual report of the National Research Council, for the period ending June 30, 1921, shows clearly the extent to which this organisation has been carried in the United States. There are divisions based on political classification, *e.g.* Federal, foreign and States relations; on functional classification, *e.g.* educational relations, research extension and information service; and, finally, on a scientific and technological classification, *e.g.* physical sciences, engineering, chemistry and chemical technology, geology and geography, medical sciences, biology and agriculture, anthropology and psychology.

A popular chemical exhibit "to show the American people what the chemist has done and may do for them," prepared by the Chemical Warfare Service of the United States Army, was held in Washington, and arrangements have been made to install it as a permanent exhibit in the United States National Museum.

The division of educational relations has given special attention to the study of the detection and encouragement of students of superior ability, and is co-operating in this investigation with the division of anthropology and psychology.

Among the projects of the division of research extension may be mentioned the following: An underwriting fund of 200,000 dollars is to be raised for the compilation of critical tables of physical and chemical constants. Measures are afoot for the establishment of a Crop Protection Institute; an Alloys Research Association; a school for tanning to be affiliated to an established university; a Textile Research Institute; and a Horological Institute of America, which will be concerned primarily with the scientific phases of time keeping with special reference to the mechanical devices necessary.

The research information service has for its purpose "to promote scientific and industrial research in this country through the operation of an active exchange for all kinds of scientific and technological knowledge." It prepared for publication Bulletin No. 9, Funds Available in 1920 in the United States of America for the Encouragement of Scientific Research, giving an account of medals, prizes, grants and research scholarships and fellowships amounting in value to approximately 36,000,000 dollars annually. In addition to research in personal records the service has a catalogue of 20,000 chemists and mining engineers, and a file of current investigations.

From the division of engineering a report embodying the results of the investigations on fatigue phenomena of metals will be published shortly. The results indicate that a rise of temperature test may

furnish a trustworthy accelerated test for fatigue resistance. It is stated that "this report contains the most valuable and complete information ever published on this subject." We shall await its appearance with much interest.

Owing to the very sudden increase in the destruction of marine piling in San Francisco Bay resulting from the attack of marine borers, which amounted in value to about 15,000,000 dollars in the last year or two, a marine laboratory has been established in San Francisco Bay and the National Research Council has taken measures for undertaking co-ordinated investigations on the problem. The report states: "This is one of the most important problems presented to the National Research Council since its organisation and one of the best illustrations of the important service which can be rendered by a national body of this sort. It is also an excellent illustration of the need for co-operation between the scientific and engineering groups."

The committee on ceramic research has selected the following four subjects to receive early attention: (1) A study of the elements which determine the plastic nature of clay; (2) a critical examination of certain methods used in silicate analysis; (3) a study of American pot clays and their proper compounding for the production of refractories used in the glass industry; (4) a study of the relationship between crazing and the expansion coefficients of bodies and glazes.

Enough has been indicated of the character of this sixth annual report of the National Research Council to convince, perhaps, even the warmest exponent of the theory of science for science's sake and of the inalienable right of the scientific spirit to go whither it will, that there is a vast field of scientific research meet for organised co-operation on national lines. J. W. W.

International Contributions to Mendelism.

THE Dutch journal *Genetica*, under the editorship of Dr. Lotsy and Dr. Sirks, has published an excellent international number as a Mendel Memorial in connexion with the recent centenary celebrations in Brünn and Vienna. In a long and carefully written article, Prof. V. Häcker (Halle) reviews the present state of knowledge of Mendelian inheritance, especially as regards cytological interpretation and other aspects of general interest. Such a cautious and well-informed statement is most valuable at the present time. Dr. E. Fischer (Zürich) describes his large series of experiments in breeding the Silver-washed Fritillary (*Argynnis paphia*) and its dimorphic female, the well-known var. *valesina*. It used to be thought difficult to get such creatures to breed in confinement, but Dr. Fischer, following a technique which he describes, has raised several thousands as the result of various matings. Prof. R. Goldschmidt (Berlin) contributes an analysis, and suggests a factorial scheme which fits the numbers fairly well. There is a dominant *valesina* factor, V, which is not sex-linked, and the combinations VV, V*v*, *vv* are possible both in males and females. Since, however, the males are all *paphia* alike, their genetic constitution can be decided only by experimental breeding. We are still as far as ever from understanding how it comes to pass that the males are thus uniform, though they may contain even two doses of the element which in a single dose suffices to give the dominant character to the female, a difficulty which has puzzled geneticists very long. There are many parallel examples in butterflies of di- and polymorphic females, though nothing analogous is ever seen in the males. The cytological scheme which so successfully represents the observed facts in colour-blindness and similar examples here apparently fails, and the special interpretations offered by Goldschmidt, though suggestive, are scarcely more than a restatement of the difficulty.

Prof. Ghigi (Bologna) discusses the origin of domesticated poultry, especially fowls and pigeons, in the light of his breeding experiments. He leans to the conclusion, which other evolutionists have also reached, that it is most difficult to suppose, as Darwin did, that the various breeds of fowls are derived simply from *Gallus bankiva*, or the pigeons collectively from the rock-dove. The plausible suggestion is here made that the heavy breeds of fowls, which constitute the main problem, may have come from some partially flightless island form, taken bodily into domestication, since nothing of the sort now survives in a wild state. Some of the pigeons, he thinks, may be derived from crosses with *Columba leuconota*, which when bred with tame pigeons gives, as he found, at least fertile males. The effect of all these appeals to multiple origins, necessary as they now appear to be, is to weaken confidence in the classical deductions as to unlimited possibilities of variation under domestication apart from cross-breeding.

Other interesting papers are those of Prof. J. L. Frateur (Louvain) on compound characters, M. A. Meunissier (Paris) on the 3-podded and other varieties of peas, and Dr. Winge (Copenhagen) on some curious and complex phenomena in Drosophila, which favour the hypothesis already entertained by several biologists that mutation may sometimes be the consequence of a rare cross-over. Dr. Sirks (Wageningen) recounts his experiments with a new subspecies of *Linaria vulgaris*, giving a mixed F_1 generation in crosses with the wild type, an unexpected result which may be variously interpreted. A remarkable experiment is also described by Prof. J. Schaxel (Jena), who succeeded in grafting together limb-buds of the coloured and the white forms of Axolotl, producing limbs compounded of both elements so intimately associated that the name "Chimæra" may be applied to them, on the analogy of Winkler's famous graft-hybrids made between the tomato and *Solanum nigrum*.

This collection of memoirs reaches an unusually high level. All contain material of permanent value.

The Oldebroek Explosion of October 28, 1922.

IN NATURE of November 4, p. 619, a preliminary note appeared on the great explosion at Oldebroek. It is now possible to discuss more fully the results obtained.

About 140 reports were received from observers in the British Isles. Of these, nearly one-third stated that despite careful listening they heard no sound that appeared to be due to the explosion.

When the distribution of the positive and negative reports is studied, the most notable feature is the entire absence of positive reports from the greater part of the Midlands of England. With regard to Europe generally, it appears that the sound was reported so far off as 850 km. to E.S.E., 600 km. to S. and 700 km. to N.W. of Oldebroek, whereas no single trustworthy observation was reported in a zone

between the limits of 100 and about 180 or 200 km. radius. Confirmation of the existence of a "Silent Region" was therefore once more obtained. Also, the times which the sound waves took to reach various distances are in most cases longer than they would be for normal propagation through the surface air.

The accuracy of the time standard of the average non-scientific observer is not likely to be high, but when the British observations are classified with reference to apparent velocities of propagation, there appears to be some evidence that these tend to group themselves about points corresponding to velocities of 257, 335, 370, and 508 metres per second. The second group corresponds very closely to propagation through the surface layers of air, due allowance being made for temperature and wind. In view of the uncertainty as to the accuracy of the observed times, it is doubtful whether the observations of the third group are to be regarded as truly distinct from those of the second, but it is just possible that this velocity is to be explained by the assistance of a strong north-easterly wind, and, though there is no actual measurement, it is not improbable that such a wind may have existed somewhere about the three- or four-kilometre level. At a height of one kilometre the mean wind over south-east England was north-easterly 15 m/s, and at a height of two kilometres E.N.E. about the same velocity. A *ballon sonde* reaching 9 km. indicated a resultant drift for the whole trajectory from about N.N.W., and a cirrus cloud observation obtained in Holland indicated an apparent velocity equivalent to 33 m/s from W.N.W. at a height of 10 km.

Of special interest are the first and fourth groups with velocities centring at 257 and 508 m/s respectively. Five of the seven observations indicating the latter velocity were made at very considerable distances from Oldebroek, namely at Newcastle, Bolton-le-Moors, Skipton-in-Craven, Northallerton, and Guernsey. Prof. E. van Everdingen is of opinion that such observations and the proven existence of the "Silent Region" afford very strong evidence of the co-operation of the hydrogen atmosphere. The view that the appearance of silent regions is to be ascribed to a change in the constitution of the atmosphere at great heights was put forward by Von dem Borne in 1910. Making certain assumptions as to the constitution at great heights, he calculated that the shortest possible distance at which sound rays, curved back by this high atmosphere, could reach the surface was 114 km., the ray becoming horizontal at a height of 75 km. Actually no case of so short a distance has yet been found. In 1915 van Everdingen, taking Wegener's hypothesis as to the occurrence of geocoronium in the atmosphere and his percentage values as to constitution, showed that it gave no better a result. On testing various hypotheses, the best results appeared to indicate a percentage of hydrogen at surface level of 0·0001.

In addition to the observations discussed above collectively, certain special observations were made in this country. The Acoustical Research Section of the Signals Experimental Establishment contributed most valuable records obtained by means of hot wire microphones at Woolwich and at Biggin Hill, Kent. These were described and discussed in detail by Major W. S. Tucker in a paper to the Royal Society of Arts on November 29. In the case of the Biggin Hill record he attributes the first effect (indicating a velocity of nearly four times that of sound in air) to propagation through the water and the ground.

At Eskdalemuir Observatory at 17 h. 29 m. G.M.T. a small upward movement of about one-thirtieth of a millibar on the microbarograph record was followed about 13 minutes later by an approximately equal one in the opposite direction. On the traces of the other instruments, including the seismographs, no evidence of an explosion effect is to be found. Mr. J. J. Shaw (West Bromwich) could also find no evidence on his seismograms, but stated that at the critical time many thousands of pedestrians and heavy vehicular traffic (the returning crowd from a football match) were passing his house.

The collected observations of the various European countries are now being investigated by Prof. van Everdingen of the Dutch Meteorological Service.

University and Educational Intelligence.

AMONG University Extension agencies the Summer School plays an increasingly important part. This year eleven universities and university colleges in Great Britain were responsible for at least fifteen summer schools, not counting those organised by joint committees for tutorial classes in connexion with the Workers' Educational Association. In the United States, summer courses are provided in numbers and on a scale far in excess of anything that has been attempted elsewhere. The Bureau of Education, Washington, has published a Bulletin on the subject (1922, No. 31) in which are shown the student enrolments in last year's summer schools of the twenty-seven universities and colleges which sent representatives to the meeting of the Association of Summer School Directors. The largest were: Columbia 11,809, Chicago 6458, California 6176, Wisconsin 4547. Fourteen other institutions had enrolments exceeding 1000 each. On the other hand, many of the best known, including Yale, Princeton, Vassar, and Brown, do not receive summer students: Yale experimented with the system for three years and then gave it up. Some of the most conservative colleges, while not undertaking summer schools of the ordinary type, have opened their doors in the summer for conferences and for special classes designed to establish contact with industrial workers. Many hesitate, as do universities in this country, to increase their commitments in this direction for fear of financial difficulties. State universities regard the matter in a different light, and find that this and other forms of extension work help to justify in the eyes of the taxpayers their large demands on the public purse. In general the courses are devoted principally to the liberal arts and sciences and to education, but some schools of law, medicine and dentistry offer courses which count for their degrees, and in a few institutions engineering and architecture courses are provided.

FROM the Royal Technical College, Glasgow, we have received a copy of their annual report on the work of the session 1921–22. Owing to the cessation of special classes held at the request of the Ministry of Labour under their "Interrupted Apprenticeships" Scheme, the number of students was slightly lower than in 1920–21, but compared with 1913–14 the year's enrolment shows an increase of 150 per cent. The research work carried on in the college is extending rapidly in volume and importance, especially in chemistry, metallurgy, and engineering. Much of it is undertaken at the instance of industrial research associations by the associations' own workers under the supervision and guidance of the professors concerned. The course for the diploma in chemistry, recently extended from three to four years, includes in its final year three months devoted to experimental inquiry, on which a thesis is required to be written. This plan has been an unqualified success, the report says, from an educational point of view, and some of the theses presented last year were of such intrinsic

value as to warrant publication. In more than a hundred centres in the surrounding counties affiliated continuation classes in science and technology were conducted by education authorities: nearly all evening students entering the college, except those from a considerable distance, present qualifications gained in such affiliated classes. The school of pharmacy is now thoroughly established, and several students are preparing for the B.Sc. degree in pharmacy of the University of Glasgow.

RECENT developments in the Swedish national school system are described in an article by Prof. Hänninger of the Landskrona Training College in the November number of *School Life*—an official journal of the United States Bureau of Education. In 1919 the Government prescribed for use in the folk-schools a new instruction plan, the outstanding feature of which is "home and community study," involving lessons based on direct observation of the environment of home and school and linking the observed facts with geography, nature-study, history, drawing, and sloyd. About the same time were established two-year continuation schools with a total of 360 hours of instruction, directed in the main on practical lines, and including citizenship and the mother-tongue, and either a craft or natural history, sloyd, and horticulture. These schools are to be obligatory after 1924. Apprentice schools with two-year curricula, for which the continuation schools serve as a preparation, may be made compulsory at the option of the local community. In the apprentice schools the instruction comprises 6 to 12 hours per week during 8 or 9 months of the year. Beyond it is an optional crafts school with a one-year course. In a report just issued by a Grand School Commission proposals are made for substituting for the existing dual system (folk-school and *realskola*) a common foundation school to be attended by children of all classes for six years, leading to a middle school with a four-year course, to be followed by a three-year "gymnasium."

HIGHWAY Engineering and Highway Transport Education problems were discussed at a conference held at Washington on October 26-28, under the auspices of the United States Highway Education Board. Between 1910 and 1922 the number of motor vehicles increased 2000 per cent. (to ten and a half millions), while the increase in funds for road building was only 400 per cent. Neither highway construction nor highway transport education have kept pace with the stupendous increase in automobile traffic. The trend in the colleges at present is towards a system whereby certain fundamental courses covering about 5 semester hours in highway engineering are required of all civil engineering students, while an equal amount of optional supplementary highway instruction in the subject is offered for intending specialists.

IT is announced in the *British Medical Journal* that the University of Paris has received two gifts of 100,000 francs each from Madame Edouard Nathan. The first of these is to be applied to the improvement of the scientific laboratories of the University, and to the promotion of research work. The second is to be set apart for the purpose of making loans to impecunious students of the University to enable them to continue their studies.

THE *Chemiker Zeitung* of October 28 reports that Prof. Pfeiffer, of the Technische Hochschule, Karlsruhe, has been appointed Director of the "Josefine und Eduard von Portheim-Stiftung für Wissenschaft und Kunst" in Heidelberg, and will direct the Chemical Research Institute of this Fund.

Societies and Academies.

LONDON.

Physical Society, December 8.—Dr. Alexander Russell, in the chair.—G. **Shearer**: The relation between molecular and crystal symmetry as shown by X-ray crystal analysis. By X-ray analysis the number of molecules associated with the unit cell is determined. The symmetry number for each of the 32 crystal classes is shown to mean the minimum number of asymmetric molecules necessary in the unit cell to satisfy the symmetry conditions. The symmetry number is the actual number of molecules in the cell when the molecule is asymmetric; if the molecule possesses symmetry, this symmetry appears also in the crystal, and the number of molecules in the unit cell is obtained by dividing the symmetry number of the crystal by the symmetry number of the molecule.—E. A. **Owen** and G. D. **Preston**: Modification of the powder method of determining the structure of metal crystals. Plates of aluminium, iron, copper, lead, and magnesium have been examined by means of the Bragg X-ray spectrometer, employing radiation direct from a molybdenum anti-cathode. The maxima in the spectra are sufficiently intense to measure with accuracy, and the crystalline structure of the materials examined are readily determined.—A. B. **Wood**: The cathode ray oscillograph. The instrument is of the low-voltage type, in which a hot cathode is employed as a source of the electron current. This low-voltage type of oscillograph is much more sensitive than the high-voltage cold-cathode type of M. Dufour. There are various methods of focussing the cathode-ray stream, and it has been proposed to have an external (*i.e.* outside the vacuum) photographic film. Ordinary gelatin-coated roll films or plates are unsuitable, owing to the marked absorption of the cathode-rays by the gelatin. The best results have been obtained with Schumann plates containing calcium tungstate. This material phosphoresces with a light rich in ultra-violet, and consequently the secondary luminous effect on the Schumann plate is very great. Mechanical, electrostatic, and electromagnetic methods are described for generating a time-axis on the records.—R. **Webb**: A low-voltage cathode ray oscillograph. The instrument is designed to work at 300 volts. The cathode consists of a hot platinum filament coated with certain oxides, and formed into a circle coaxial with the path of the rays. It is protected from bombardment by positive rays, which would disintegrate it, by a screen in which is cut a circular hole slightly less in diameter than the filament. It has a life of about 200 hours. The anode is a platinum tube through which the rays pass. The deflecting fields are electrostatic, and are provided by two pairs of plates at right angles. The bulb is in the form of a conical flask, the cathode being at the narrow end so that the rays impinge on the flat bottom, which is coated inside with fluorescent matter. The luminous trace of the rays can be seen from outside through the bottom of the flask.

Royal Meteorological Society, December 20.—Dr. C. Chree, president, in the chair.—C. J. P. **Cave** and R. A. Watson **Watt**: The study of radiotelegraphic atmospherics in relation to meteorology. Results obtained in 1915, at the Meteorological Office Radio Station, Aldershot. Radiotelegraphic direction finding on atmospherics was introduced as a means of locating thunderstorms, and successful observations were made, with the co-operation of the Admiralty coast stations, on storms as near as five miles to an observing station, and on other storms 1000 miles distant. The first thunderstorm thus located, and

confirmed by subsequent meteorological reports, occurred in the south of Ireland on July 24, 1916, at a distance of 280 miles from the most distant station participating in its detection. A storm was traced across the Bay of Biscay and Southern France, a thunderstorm at Venice was located by two stations a thousand miles away, and a storm five miles from Aldershot was followed by the direction finder there, the bearings given being in complete agreement with the bearing of the audible thunder and the visible storm.—C. J. P. **Cave**: Winter thunderstorms in the British Islands. During the first three months of the years 1916, 1917, 1918, and 1920, the number of storms occurring in the winter months was very remarkable, there having been storms somewhere in the region on more than 40 per cent. of the days. Some of the storms were very widespread. They seem to have been connected with the occurrence of masses of air at widely different temperatures in close proximity. Thunderstorms are caused, it is suggested, (1) by the heating of the lower layers of the atmosphere, (2) by the cooling of the upper layers, (3) by a warm current of air rising over a cold one, (4) by cold air undercutting warm air.—D. E. **Row**: Forecasting sky-types. The type of pressure distribution as shown by a map or suggested by the "Further outlook" of the Meteorological Office, and the part of it which is likely to affect the locality concerned, is used, and local indications are considered. For example: Cirrus types followed by cumulus forms are to be expected during the passages of depressions, or even where overlapping occurs between an anticyclone and a depression. Indefinite areas of low or medium pressure often give very composite skies, thus yielding striking cloudscapes in which a large variety of cloud types is featured simultaneously.

DUBLIN.

Royal Irish Academy, December 11.—Prof. Sydney Young, president, in the chair.—J. J. **Nolan**: Ionic mobilities in air and hydrogen. The composite nature of ordinary ionisation in air is demonstrated by a third method. The ionisation in hydrogen is examined by the Rutherford-Franck method. The results obtained are similar to those already found for air and are, in general, confirmatory of the work of Haines. The ionisation is more complex than Haines's work would indicate, and a high degree of purity or drying is not necessary to bring out this feature. Criticisms by Blackwood are considered.

PARIS.

Academy of Sciences, December 11.—M. Émile Bertin in the chair.—Pierre **Termier**: The structure of the eastern Alps: relations of the Dinarides and the Alps.—A. **Rateau**: Pressures and specific gravities of air in a normal atmosphere.—M. H. Vincent was elected a member of the section of medicine and surgery in the place of the late M. A. Laveran.—Gaston **Julia**: Rational substitutions with two variables.—Maurice **Lecat**: The development of determinants as a function of determinants with axial empty spaces.—Lucien **Mouren**: New nomograms with aligned points applicable, in particular, to problems of navigation and their mechanical realisation.—M. Amoroso **Costa**: Concerning a note of M. Borel.—Mlle. O. **Jasse**: The Comas Sola planet of November 26, 1922: its identity with (629) Bernardina.—J. **Guillaume**: Observations of the sun, made at the Lyons Observatory during the second quarter of 1922. Observations were possible on 80 days in this quarter; the results are summarised in three tables showing the number of spots, their distribution in latitude, and the distribution of the faculæ in latitude.—L. **Décombe**: The direct calculation of the secular perihelic displacement of the planets on the hypothesis that the gravitation is of electrical origin. Application to the planet Mercury.—F. **Michaud**: The rigidity of jelly. The influence of a dissolved crystalloid. An application of a method described in an earlier note, capable of measuring a modulus of rigidity one-hundredth of that measured by Schwedoff. The effects of adding acids, bases, mineral salts, and organic substances have been studied.—A. **Dauvillier** and Louis **de Broglie**: Remarks on the work of M. E. Hjalmar concerning the M series of the elements. The measurements recently published by Hjalmar confirm the theory of the structure of the Röntgen spectra of the elements developed by the authors.—G. **Durante**: An apparatus for microphotography. Simplicity, transportability, and low cost are the advantages claimed for the apparatus described.—Georges **Déjardin**: The ionisation of mercury vapour in the presence of argon. The phenomena described in detail can be best explained by assuming that for electrons traversing an atmosphere of argon there exists a first critical velocity corresponding to about 11·3 volts, and that the resonance radiation emitted by the gas under these conditions ionises the vapour of mercury. This ionisation is not accompanied by any notable modification of the mercury spectrum.—G. **Denigès**: The rapid estimation of magnesium in a single drop of sea-water. The method is based on Schlagdenhaufen's reaction, the colour produced by the interaction of magnesium salts and potassium hypoiodite.—L. J. **Simon** and A. J. A. **Guillaumin**: Methylisopyromucic acid and a method of diagnosis of the acids of the sugar group. The dehydration of the lactone of rhamnonic acid gave methylisopyromucic acid, a description of which is given.—Marcel **Delépine**: The dipyridine iridium tetrachlorides. Configurations of the iridio-dipyridino-tetrachlorides.—M. **Picon**: The action of sod-ammonium on aniline and its homologues. Sod-ammonium (in liquid ammonia) and aniline react slowly at the ordinary temperature giving hydrogen, sodium amide, and the aniline derivative $C_6H_5.NHNa$. The last named reacts violently with ethyl bromide, giving ethylaniline. Other aryl amines behave similarly.—E. E. **Blaise**: Syntheses by means of mixed organozinc derivatives: propylglyoxal.—Léon **Moret**: The existence of the upper Cretaceous (facies "Red layers") in the Autochthone in the neighbourhood of Thônes (Haute-Savoie).—F. **Roman** and J. Royo **Gomez**: The existence of Lutecian mammals in the Douro basin (Spain).—V. **Van Straelen**: The decapod crustaceans of the Portland beds of Cerin-Marchampt.—Henri **Coupin**: The origin of the siliceous carapace of diatoms.—A. **de Puymaly**: The adaptation to aerial life of *Zygnema peliosporum*.—E. **Chauvin**: The toxicity of *Volvaria gloiocephala*. This fungus, commonly considered as poisonous, when gathered near Algiers was shown by A. Gautier to be edible without inconvenience. The author has gathered the same fungus in France (Fontainebleau) and eaten it without ill-effects.—V. **Vincent**: The measurement of the acidity of soils by alkaline liquids.—L. **Fage** and R. **Legendre**: Fishing with a submerged source of light as a means of studying the coast fauna.—Mme. Z. **Gruzewska** and M. **Fauré-Frémiet**: The maximum quantities of reserve glycogen in the livers of dogs of different ages.—L. **Garrelon**, D. **Santenoise**, and R. **Thuillant**: The parallelism between the sensibility to the oculo-cardiac reflex and the sensibility to toxic actions.—Mlle. France **Gueylard** and M. Marcel **Duval**: The comparative toxicity of various acids for fishes (*Gasterosteus aculeatus*). The hydrogen ion concentration is not the sole cause of the rapid death

of the fishes in acidified solutions: the nature of the acid has also an important influence.—Aug. **Michel**: Caudal regeneration in *Polygordius neapolitanus*.—H. **Barthélémy**: The maturation *in vitro* and the activation by puncture of the ova of *Rana fusca* at the moment of discharge from the frog.—M. **Charcot**: Preliminary report on the voyages of the *Pourquoi-Pas?* in 1922.—A. **Desgrez** and H. **Bierry**: A mode of action of Vichy waters.

WASHINGTON.

National Academy of Sciences (Proc. Vol. 8, No. 11, November 1922).—J. A. **Marshall**: Bactericidal properties of the products of radium emanation. Old radium emanation tubes which have undergone disintegration in respect of γ-ray content are crushed under Ringer's solution in a sterile mortar. The radioactive solution obtained is conveyed immediately to the infected areas by sterile dressings; in the case of abscesses at the roots of teeth, it is injected through the pulp canal. This treatment gives better results than other antiseptic agents.—H. S. **Washington**: The jades of Middle America. The jades investigated are from a sacred natural well in the ancient Maya city of Chichen Itza, in northern Yucatan. The dominant colours are grey and green. They are jadeite jades of American origin, and differ from Asiatic jadeite in the large amount of diopside in the pyroxene they contain and the presence of much albite. Analyses are given.—Carl **Barus**: On a comparison of the relative sensitiveness of telephones. An interferometer U-gauge is connected by a quill tube to the telephone mouthpiece and a relation is obtained between the fringe movements and the constants of the instrument.—Carl **Barus**: The equilibrium positions of the vacuum gravitation needle in 1921 and 1922. From the curves given, the variations of the position of equilibrium in the lapse of time are of a different order in 1922 from their approximate constancy, in the given scale, in 1921. This may be due to the difference in the vacua obtained. All observations have a period of 24 hours, indicating solar radiation as the origin of the variations.—W. W. **Coblenz**: Further measurements of stellar temperatures and planetary radiation. (See NATURE, December 30, p. 886.) H. A. **Lorentz**: Proof of a theorem due to Heaviside. The theorem in question is: "The whole work done by impressed forces suddenly started exceeds the amount representing the waste by Joule-heating at the final rate (when there is any), supposed to start at once, by twice the excess of the electric over the magnetic energy of the steady field set up."—A. J. **Lotka**: The stability of the normal age distribution. There is an age distribution which, in certain circumstances, perpetuates itself when once set up in a population. An analytical method is used to show that this distribution is stable and that a population spontaneously reverts to it if the age distribution be displaced.

Official Publications Received.

Journal of the Indian Institute of Science. Vol. 5, Part 4: Induction Motors used as Synchronous Machines. By S. V. Ganapati and R. G. Parikh. Pp. 37-46+9 plates. 1.8 rupees. Vol. 5, Part 5: The Relation between the Iodine Values and Refractive Indices of some hardened Vegetable Oils. By J. J. Sudborough, H. E. Watson, and D. Y. Athawale. Part 1. Pp. 47-69+3 plates. 1.8 rupees. (Madras: Indian Institute of Science.)

Imperial Department of Agriculture for the West Indies. Report on the Agricultural Department, Dominica, 1921–22. Pp. iv+32. (Barbados.) 6*d*.

The British Mycological Society. Transactions. Vol. 8, Parts 1 and 2, December. Pp. 111. (London: Cambridge University Press.) 15*s*. net.

Leeds University. Eighteenth Report, 1921–22. Pp. 190. (Leeds.)

Ministère de l'Instruction publique et des Beaux-Arts. Enquêtes et documents relatif sà l'enseignement supérieur. 117: Rapports sur les observatoires astronomiques de Province. Année 1921. Pp. 127. (Paris: Imprimerie Nationale.)

Diary of Societies.

SATURDAY, JANUARY 6.

ASSOCIATION OF WOMEN SCIENCE TEACHERS (at University College), at 2.30.—Dr. Dorothy Wrinch: Relativity.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. H. H. Turner: Six Steps up the Ladder to the Stars (5). Two Great Streams of Stars (Juvenile Lectures).

GILBERT WHITE FELLOWSHIP (at 6 Queen Square, W.C.1), at 3.—G. J. B. Fox: A Visit to Pompeii.

MONDAY, JANUARY 8.

INSTITUTION OF ELECTRICAL ENGINEERS (Informal Meeting), at 7.—E. W. Moss, and others: Discussion on the Protection of Inventions by Letters Patent.

ARISTOTELIAN SOCIETY (at University of London Club, 21 Gower Street), at 8.—Rev. Leslie J. Walker: A New Theory of Matter.

SURVEYORS' INSTITUTION, at 8.—F. W. Hunt: Zoning in the Control of Large Cities.

TUESDAY, JANUARY 9.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Prof. H. H. Turner: Six Steps up the Ladder to the Stars (6). The Size of a Star. (Juvenile Lectures.)

SOCIETY FOR THE STUDY OF INEBRIETY (at Medical Society of London), at 4.—Dr. H. Campbell and others: Discussion on The Pathology and Treatment of Morphia Addiction.

INSTITUTION OF PETROLEUM TECHNOLOGISTS (at Royal Society of Arts), at 5.30.—Dr. W. R. Ormandy and E. C. Craven: Further Investigations into the Physico-Chemical Significance of Flash-Point Temperatures.

MINERALOGICAL SOCIETY (at Geological Society), at 5.30.—A. Brammall and H. F. Harwood: Dartmoor Granite: (*a*) Rutile, Brookite, and Anatase: Genesis. (*b*) Varieties of Zircon: their significance.—Dr. A. Hutchinson: A Graphical Method of Correcting Specific Gravity Determinations.—Dr. L. J. Spencer, with microscopical determinations by W. Campbell Smith, and chemical analyses by E. D. Mountain: A Davyne-like Mineral and its Pseudomorphs from St. John's Island, Egypt.

INSTITUTION OF CIVIL ENGINEERS, at 6.—H. W. H. Richards: Twelve Years' Operation of Electric Traction on the London, Brighton, and South Coast Railway.

INSTITUTE OF MARINE ENGINEERS, INC., at 6.30.—H. Campbell: Gas Engines, and Gas Producer Plants.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Scientific and Technical Group), at 7.—H. W. Greenwood: The Manufacture of Paper for Photographic Purposes. Historical—Hand-made Paper—Machine-made Paper—Raw Materials—Preparation—Beating—Sizing—Making—Finishing and Baryta Coating. Faults of Manufacture and their Effect on Emulsions—Testing for Faults, Impurities, etc.

QUEKETT MICROSCOPICAL CLUB, at 7.30.—Various Members: Notes on Mounting.

CIRCLE OF SCIENTIFIC, TECHNICAL, AND TRADE JOURNALISTS (at Institute of Journalists), at 8.15.—Sir Richard Gregory and others: Discussion on Reviews and Reviewers.

WEDNESDAY, JANUARY 10.

ROYAL SOCIETY OF ARTS, at 3.—C. R. Darling: The Spectrum, its Colours, Lines, and Invisible Parts, and some of its Industrial Applications (Dr. Mann Juvenile Lectures (2)).

GEOLOGICAL SOCIETY OF LONDON, at 5.30.

INSTITUTION OF ELECTRICAL ENGINEERS (Wireless Section), at 6.—C. F. Elwell: Design of Radio Towers and Masts: Wind Pressure Assumptions.

INSTITUTION OF AUTOMOBILE ENGINEERS, at 7.30.—Col. P. H. Johnson: Improvements in Efficiency of Roadless Vehicles.

THURSDAY, JANUARY 11.

ROYAL AERONAUTICAL SOCIETY (at Royal Society of Arts), at 3.—R. A. Frazer: Testing Model Seaplanes (Juvenile Lecture).

OPTICAL SOCIETY (at Imperial College of Science and Technology), at 7.30.—C. Davidson: The Amount of Displacement in Gelatine Films shown by Precise Measurements of Stellar Photographs.—J. E. Barnard: The Use of Ultra-violet Light in Microscopy.—F. W. Preston: Pitch.—T. Y. Baker: A Prismatic Astrolabe.

INSTITUTE OF METALS (London Section), (at Institute of Engineers, Inc.), at 8.—W. E. Hughes: Some Aspects of Electro-deposition.

CAMERA CLUB, at 8.15.—J. S. Wells: Criticism of Members' Prints.

FRIDAY, JANUARY 12.

ROYAL ASTRONOMICAL SOCIETY, at 5.—Prof. A. S. Eddington and A. V. Douglas: The Progression of Stellar Velocity with Absolute Magnitude.—J. Evershed: Note on the Corona of 1908.

MALACOLOGICAL SOCIETY (at Linnean Society), at 6.

INSTITUTION OF HEATING AND VENTILATING ENGINEERS, INC. (at Engineers' Club, Coventry Street), at 7.—Dr. B. R. Wingfield: Automatic Temperature Control.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—S. A. Stigant: Transient Phenomena arising in Transformers from Switching Operations.

ROYAL SOCIETY OF MEDICINE (Ophthalmology Section), at 8.30.—H. Butler: Some Unusual Cataract Operations.—C. Killick: The Treatment of Conical Cornea.

SATURDAY, JANUARY 13.

GILBERT WHITE FELLOWSHIP, at 2.15.—Visit to the Geological Museum, Jermyn Street.