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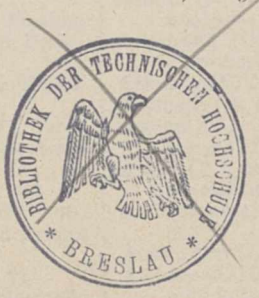
"To the solid ground
Of Nature trusts the mind that builds for aye."—WORDSWORTH.



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

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Problems of Geochemistry.

IN his recent lecture at the Royal Institution, parts of which are reproduced in this issue of NATURE, Prof. V. M. Goldschmidt presented a brilliant summary of the broader problems of geochemistry and of some of the conclusions that have been reached in the effort to solve those problems. His view of the concentric architecture of the earth, and in particular of the 'eclogite' and 'sulphide-oxide' shells, is one that has received much more attention on the Continent than in the English-speaking countries. In Britain and America the substratum between the crust and the core is more generally supposed to be of the composition of peridotite. More important, however, than a reminder of such differences of opinion, is Prof. Goldschmidt's summary of the principles which enable geochemistry to enter into partnership with geophysics in the difficult investigation of our planet's hidden depths. The laws that govern the vertical distribution of the chemical elements, their partition between the different shells of the earth, are gradually being recognised, and their integrated effects can be tested by an appeal to the zones that are accessible to observation. Conversely, the composition of these zones affords a valuable series of clues as to the nature of the deeper layers. In particular, the abundance of iron among the predominating lithophile elements of the crustal rocks gives a clear indication that iron must be the chief constituent of the core. Confirmatory evidence is forthcoming from the samples of other cosmic bodies which, as meteorites, are captured by the earth. They, too, have their nickel-iron phases and their silicate phases, in close analogy with the composition assigned on

technological grounds to the principal parts of the earth.

The analogy is, unfortunately, not a safe one to follow too far, since many meteorites bear distinct signs of having had a volcanic origin, and none that has yet been discovered represents the mineral assemblage of the high-pressure or 'eclogite' facies of silicate rocks. Nevertheless, meteorites provide precious data bearing on the natural association of elements, and these, together with spectroscopic evidence of the composition of stellar atmospheres, are found to be closely in accordance with the associations characteristic of our own terrestrial materials.

Less speculative, but of absorbing interest and economic importance, is Prof. Goldschmidt's discussion of the concentration of the rarer elements in the residual liquors of magmas. Corresponding with his deduction that two very different types of elements would be expected to remain in the final liquors, we find in pegmatites minerals of elements with very small atomic sizes (for example, lithium, boron, and fluorine) associated with others containing the large-size elements (for example, zirconium, thorium, uranium, niobium, and tantalum). It has frequently been asserted that the heavy radioactive elements might be expected to be concentrated in the deeper and heavier levels of the earth's interior. The geochemistry of both igneous rocks and meteorites affords no support to this superficial view, but indicates, on the contrary, that these markedly lithophile elements, ultimately sorted out in virtue of their atomic sizes, should be steadily concentrated in the uppermost levels of the earth's crust, the effect being cumulative with each successive igneous cycle.

Geochemistry has before it a broad and attractive field to cultivate. Not only the *vertical* distribution of elements, but also their *horizontal* distribution needs to be correlated with geological structure and geological history, and finally there remains for much further study the geochemistry of the secondary geological processes such as weathering, sedimentation, and metamorphism. Prof. Goldschmidt, more than any other single investigator, has developed the principles and methods most likely to yield a rich harvest. They deserve particular attention in Great Britain, where geochemistry has been somewhat neglected, for, as his stimulating lecture clearly reveals, their application to problems of petrogenesis and ore-deposition, as well as to the material aspects of geological processes in general, is already achieving a series of encouraging results.

Low-Temperature Carbonisation.

The Technology of Low Temperature Carbonization. By Frank M. Gentry. Pp. xvii + 399. (London : Baillière, Tindall and Cox, 1928.) 34*s*. net.

WHEN coal is burned in open grates, and, indeed, in many industrial furnaces, a large proportion of the volatile contents of the coal escapes into the atmosphere unburnt, or but partially burnt, in the form of oily vapours and particles of soot. The resulting pollution of the atmosphere, particularly in large residential centres, is a serious civic problem, resulting in much defacement of buildings and impoverishment of health.

With, possibly, one or two exceptions, our smoke abatement laws are framed to restrict the discharge of smoke from industrial stacks as distinct from domestic chimneys. In most large cities, however, the smoke nuisance arises mainly because bituminous coal is burned in domestic grates.

The discharge of smoke from industrial stacks is much less to-day than it was twenty years ago, because the scientific investigation of combustion processes has led to a great improvement in the design and operation of furnaces. With few exceptions, the discharge of smoke from a factory stack is unpardonable and indicates a lack of scientific control in the furnace room.

The increasing use of gas and electricity, and the correspondingly diminished amount of bituminous coal that is burnt in domestic fireplaces, is reflected in lower concentrations of smoke in the atmosphere above large cities. There still remains, however, much room for, and indeed much need of, improvement, and this improvement can be brought about mainly by preventing the discharge of smoke from domestic chimneys. To some extent this will be accomplished automatically by the further development of gas and electric heating. It is unlikely, however, that coal as a domestic fuel will be completely displaced by these alternatives for many years to come.

It is possible to prevent this smoke formation by removing the volatile constituents from the coal before it is burnt in the grate. This is already done in the gasworks, but the resulting coke is difficult to ignite and cannot readily be burnt on domestic grates. If the volatile constituents could be removed from the coal and a residue be obtained which would burn freely and give out plenty of heat, and which could be obtained at a price comparable with that of coal and, at the same time, yield a profit on the undertaking, the use of this residual material would, conceivably, become

general and the discharge of smoke from domestic chimneys would become a thing of the past.

This is one motive for the investigation of the low-temperature carbonisation of coal. There is another: To the chemical engineer, coal is something more than a fuel; it is a complex raw material, from which, by suitable means and with the appropriate plant, many valuable liquid and gaseous products can be obtained, leaving a solid residue which is still a valuable combustible. These products may be used in various ways—for example, as fuel for internal combustion engines, as lubricants, as fertilisers, or as starting materials for the manufacture of a wide range of organic compounds.

To separate a volatile fuel oil from coal and burn it in an internal combustion engine is to use it more conveniently and more efficiently, so that its form value is increased. To use a separated constituent as a raw material in chemical industry is better than burning it, however efficiently, along with the parent coal.

The problem before the chemical engineer, therefore, is the development of a process by which the full potential chemical value of the coal can be realised most completely, not simply by burning the coal with the highest efficiency under a boiler, or even in powdered form in an internal combustion engine, if that were possible, but by obtaining its various components in the forms in which they will possess the highest industrial value. The immediate problem of low-temperature carbonisation is the design of a retort in which the preliminary separation can be carried out efficiently and economically.

To some extent this ideal has been realised in the by-product recovery coke oven and the gas retort; owing to the high temperature at which these processes operate, however, a large proportion of the volatile constituents of the coal is converted into gas. By carrying out the destructive distillation of the coal at lower temperatures, it is possible to obtain a smaller proportion of gas and a correspondingly greater quantity of oils. The solid carbonaceous residue, unlike the products of the coke oven and the gas retort, is very reactive, ignites readily, and burns on a domestic grate freely and without smoke. Its superior reactivity may make it suitable for special purposes and ultimately enhance its market value. Low-temperature, or 'primary', tar differs both chemically and physically from the high-temperature tar from gas retorts or coke ovens. A special technique has yet to be worked out for its subsequent treatment and evaluation.

Most of the earlier work on low-temperature carbonisation was carried out in Great Britain and in Germany; a considerable amount of work has also been done in America. Some hundreds of processes have been worked out in the laboratory; many of these have been worked on a semi-technical or technical scale, and a few of them are now being operated tentatively as large industrial units.

It is difficult, at present, to estimate the economic possibilities of low-temperature carbonisation. An immense amount of work has been done upon the design of a suitable retort, particularly in relation to the materials of construction, the movement of the charge through the retort, and the economical utilisation of the heating medium. Economic success will also depend upon the market value of the products. This value cannot yet be fully realised, for the subsequent separation and utilisation of the somewhat peculiar products still remain to be worked out. It would seem that ultimate success depends upon reducing the cost of carbonisation below a few shillings per ton, discovering new uses for primary tar and gases so as to make them more valuable than the present by-product tar and gas from high-temperature processes, or finding a use for the solid residue which will enable it to bring in a revenue equivalent to the original value of the coal. It is possible that, when satisfactory processes are developed, they may be encouraged by a Government subsidy in the interests of public health and civic well-being.

Mr. Gentry has done a great service to all who are interested in the more effective utilisation of coal by writing a most excellent and comprehensive critical account of the work that has already been done in this field. He has produced a book of nearly four hundred pages which is packed with trustworthy information and sound criticism. After a preliminary chapter dealing with the fundamental principles involved in the heating and destructive distillation of coal, separate chapters are devoted to the production and properties of the various products of low-temperature carbonisation: gas, tar, coke, and nitrogenous and other by-products. In each chapter, the various factors which affect the yield and character of the particular product, such as the character of the coal, the rate of heating, the character of the gaseous atmosphere and the secondary decomposition of primary products, are clearly discussed. Some fifty pages are then devoted to a detailed description of a number of typical plants and processes, the characteristic features of each being well described. After a valuable chapter dealing with the design and operation of

different retorts, the behaviour of various construction materials under low-temperature carbonisation conditions and the transfer of heat through these materials, the book closes with a thoughtful and stimulating chapter in which the economics of low-temperature carbonisation are carefully considered. Such important matters as the yields of the different products and the resulting revenue, capital and operating costs, actual and potential markets for the different products, and the influence of plant location and fuel supplies, are discussed fully.

This is the best up-to-date account of the subject that is known to the reviewer. The immense amount of information is handled in a masterly manner; it has been well chosen; it is arranged logically and clearly; the conclusions are well found and clearly presented. The book is well illustrated. Its value is enhanced by more than four hundred references to original papers.

The book can be commended confidently to all who need a clear and authoritative account, from the theoretical or practical aspect, of the low-temperature carbonisation of coal. W. E. G.

Mathematical Notation through the Centuries.

A History of Mathematical Notations. By Prof. Florian Cajori. Vol. 1: *Notations in Elementary Mathematics.* Pp. xvi + 451. (Chicago and London: The Open Court Publishing Co., 1928.) 25*s.* net.

THE work before us constitutes an important contribution to the history of mathematics. The development of mathematical notation is a fascinating subject in itself; but, the literature being so vast and scattered, it is difficult, without such a guide as is here presented, to study it effectively; in fact, apart from such a vademecum, it would be necessary to spend years (almost) in studying the original documents in the great libraries. Now, however, thanks to the labours of Prof. Cajori, which must have been colossal, we are given a conspectus of the whole subject so far as elementary mathematics are concerned.

The work was originally intended to be brought out in one volume, but the author, on second thoughts, decided (wisely, as we think) to divide it into two volumes, and to confine the first of the two to the history of symbols in elementary mathematics, "since such a volume would appeal to a wider constituency of readers than would be the case with the part on symbols in higher mathematics". As it is, the volume before us is as large as can be conveniently handled. It contains, however, everything which a student of the subject is likely to require. Besides many hundreds of references to the literature, it gives extracts from all the known books, from the invention of printing onwards, which are significant from the point of view of notation, more than a hundred facsimiles of printed pages, and reproductions of similar matter from MSS. showing still earlier stages in the development of various signs.

After a page of introduction, Part II. deals with numeral systems and symbols (Babylonian, Egyptian, Phœnician and Syrian, Hebrew, Cretan, Greek, early Arabian, Roman, Peruvian, Aztec, Maya, Japanese, Chinese, and finally the Hindu-Arabic numerals). Part III. is devoted to the symbols used in arithmetic and elementary algebra, and Part IV. to those belonging to elementary geometry. Part III. is in two sections. The first (A) describes the symbols, in chronological order as it were, under individual authors, Greek, Hindu, Arabic, Byzantine, and finally medieval and modern, the latter arranged according to periods and countries. This section contains the facsimiles of passages from MSS. and of printed pages from the earliest printed arithmetic (the Treviso Arithmetic, 1478) onwards. Among them are specimens from MSS. of Nicole Oresme (14th c.), Regiomontanus and Nicolas Chuquet (15th c.), and printed pages of works by Paciuoli, Cardano, Tartaglia, Bombelli, Widman, Schreiber (Grammateus), Christoff Rudolff, Stifel, Stevin and Girard, Nuñez, Recorde, Leonard and Thomas Digges, Peletier, Vieta, Harriot, Hérigone, Descartes, Barrow, Rahn, Wallis. There is also an elaborate account of the symbols (some 150 in number) used by William Oughtred, whose influence in this regard was second to none; after him the important names are those of Barrow, Wallis, and Leibniz.

In reading Section A of Part III. the reader is in danger of not seeing the wood for the trees, so bewildering is the variety of the symbols used by the several authors; but here Section B comes to our assistance. In this, Prof. Cajori gives what he calls a "Topical Survey of the Use of Notations". The object of the history is, as he says, to give not only the first appearance of a symbol and its origin (where possible), but also to indicate the competition encountered and the spread of the symbols among writers in different countries, the rise of certain symbols, their day of popularity, their eventual decline, and so on. It is this special survey in Section B which is perhaps the most

valuable portion of the work, for in it the author presents " a mirror of past and present conditions in mathematics ", in the belief that " the successes and failures of the past will contribute to a more speedy solution of the notation problems of the present time ".

Among interesting details in the volume we may note the following. It is curious to find that the signification of numbers by knots in strings appears in Peru under the Incas and also in the earliest Chinese system, that the Maya of Central America had a numeral system which was vigesimal except in the second step, where 18 took the place of 20, and that the Maya system exhibited the principle of ' place value ' and the use of a symbol for zero about the beginning of the Christian era, and therefore centuries before the Hindus began to use their symbol for zero.

It appears that the + and − signs used in print for the first time by Widman (1489) are found in MSS. of 1481 and 1486, now at Dresden, which were studied and annotated by Widman. The sign = for equality, which we owe to Robert Recorde (" The Whetstone of Witte ", 1557), seems to have been used independently about the same time (between, say, 1551 and 1568) by a mathematician at Bologna. The signs > and < for ' greater than ' and ' less than ' are due to Harriot (1631); they ousted less convenient signs used by Oughtred about the same time. A curiosity is Hérigone's use of ' 2|2 ' for ' equal ', ' 3|2 ' for ' greater than ', and ' 2|3 ' for ' less than ' (1634, 1644). Descartes used for ' equal ' a sign like our sign for ' varies as ', but turned the other way; the sign for ' varies as ' was introduced by W. Emerson (" Doctrine of Fluxions ", 3rd ed., 1768). The sign × for multiplication was first used by Oughtred; the substitution for it of a simple dot is due to Leibniz (about 1698). ÷ for division was introduced by the Swiss, Johann Heinrich Rahn (" Teutsche Algebra ", 1659); it had previously been used in the sense of ' minus ' (Adam Riese, 1525), and, very oddly, persisted in that sense in German and Scandinavian countries until the nineteenth and even the twentieth century.

Oughtred first represented proportion by A . B : : C . D (1631); but so early as 1651 Vincent Wing wrote A : B : : C : D; Leibniz substituted A : B = C : D in 1693. The struggle between these notations is well described (pp. 286-297), as also the contest between the German + and − and the Italian and French p and m for plus and minus (pp. 135-6); the latter lasted for about 130 years. The competition between signs for radicals was more bewildering; " altogether there were at the close of the sixteenth century twenty-five or more varieties of symbols with which the student had to be familiar if he desired to survey the publications of his time ". The sign ∴ for ' therefore ' appears for the first time in Rahn's " Teutsche Algebra " (1659), with ∵ as a variant. This book was translated into English by Thomas Brancker and published in 1668 with additions by John Pell, the sign ∴ for ' therefore ' being thenceforth adopted, with a tendency to use both ∴ and ∵, until the latter sign came to be appropriated for ' because '. The sign ∞ for infinity was first used by Wallis (1655).

In the region of elementary geometry there have always been sharp divisions of opinion on the advisability of using symbols and the proper limits to their use. Barrow and Wallis, for example, were enthusiastic for symbols. Wallis used so many in his ' De sectionibus conicis ' that Thomas Hobbes protested: " And for your conic sections, it is so covered over with the scab of symbols that I had not the patience to examine whether it be well or ill demonstrated." . . . " Symbols are poor, unhandsome, though necessary scaffolds of demonstration . . . though they shorten the writing, yet they do not make the reader understand it sooner than if it were written in words. For the conception of lines and figures . . . must proceed from words either spoken or thought upon. So that there is a double labour of the mind, one to reduce your symbols to words, which are also symbols, another to attend to the ideas which they signify." The reaction, so far as geometry is concerned, came with Keill's and Simson's editions of Euclid (1713 and 1756). Keill, referring to Barrow's Euclid, wrote: " Barrow's demonstrations are so very short and are involved in so many notes and symbols that they are rendered obscure and difficult to one not versed in geometry. There, many propositions which appear conspicuous in reading Euclid himself, are made knotty, and scarcely intelligible to learners, by his Algebraical way of demonstration." The influence of Simson lasted until the time of Todhunter's edition.

It is a pity that, in a few cases, Prof. Cajori does not seem to have used the latest editions of the texts. Thus the form of the quotations from Diophantus and Heron on pp. 26, 27 would have been slightly different if they had been taken from Tannery's and Heiberg's editions rather than those of Bachet and Hultsch. The reference to Diophantus' " Arithmetica, vol. 4, p. 17 " should be to Prop. 16 of Book 4 of that work. T. L. H.

Plants of the Balkans.

The Plant-Life of the Balkan Peninsula: a Phytogeographical Study. By Dr. W. B. Turrill. (Oxford Memoirs on Plant Geography.) Pp. xxiii + 490 + 10 plates. (Oxford: At the Clarendon Press; London: Oxford University Press, 1929.) 30*s*. net.

THE valuable series of memoirs on plant-geography edited by Profs. Engler and Drude under the title "Die Vegetation der Erde" is familiar to every well-equipped botanist. But, as Prof. A. G. Tansley remarks in his editorial preface to the present volume, it is scarcely creditable to the Empire which possess in its dominions, colonies, and dependencies more varied vegetation than any other political entity, that Dr. Leonard Cockayne found himself obliged to publish his work on New Zealand in the German series. It is hoped that Dr. Turrill's memoir on the plant-life of the Balkan Peninsula may inaugurate a channel of publication to be known as the Oxford Memoirs on Plant Geography, and that the enterprise will be adequately supported.

Dr. Turrill's special interest in the Peninsula began with his service with the British Salonica Forces during the War, since when he has paid three visits to the area. His position as assistant in the Kew Herbarium has given ample opportunity for the detailed taxonomic work. The result is an authoritative combination of a taxonomic and ecological study of the area, embodying a vast amount of information conveyed in a more or less readable form.

The penalty of specialisation is brought home to the reader when perusing a volume such as this. The presentation of the plant-life of an area, so full of botanical interest as is the Balkan Peninsula, should appeal to every true botanist, and we would suggest to the editor that a glossary of the less common technical terms would smooth the way for the reader of those future memoirs which will, we trust, follow Dr. Turrill's.

The Balkan Peninsula is an irregularly triangular mountainous land-mass projecting from its base in Central Europe into the Mediterranean basin, and representing two main climatic areas, the Central European and the Mediterranean. Crete and the other islands to the south and east are also included in the survey. In the earlier chapters, Dr. Turrill describes in detail the physical features of the score or so of districts into which he subdivides the area, the geology and soil-characteristics, and the climate. Successive chapters are given to duration and life-forms of the species, flowering periods, habitat classification, altitudinal zonation, plant-communities, plant-succession, influence of man, cultivated crops, a summary of floristic and phytogeographical data for the families of flowering plants represented, plant-dispersal, floristic and vegetational distribution within and outside the Peninsula, and endemic and relict species and the age and area hypothesis, and finally there is a brief chapter of general conclusions.

The flora of the Peninsula is richer than that of any other area of equal size in Europe, not only in number of species but also of endemics, and amongst the latter are many relicts of the Tertiary flora. Two main types of flora and of vegetation are recognised: the Mediterranean, characterised by species adapted to surviving a summer drought; and the Central European, composed of species having a winter resting phase. The author lays great stress on the modifying influence of man, who, especially by forest destruction, has induced enormous changes in the flora and vegetation. Brush-woods, heaths, stony grassland, and rock-communities occupy much ground which should, under the existing climatic conditions, be covered with high forest. Hence species suited to such habitats have been able to extend their distributional areas, and much hybridisation has resulted from their resulting contact with other species. Turrill emphasises the importance of a study of the least disturbed parts of the Peninsula, such as the Rodope massif and the Strandja Planina, before the natural vegetation is further destroyed or modified by man's exploitation.

The absence of a continuous impassable barrier separating Central Europe from the Balkan Peninsula has made the latter the most important 'area of refuge', as evidenced by the number of relict species and types, dating from Tertiary times. Owing to the comparatively small influence of the Ice Age on its flora, the botanical history of the Peninsula has been more static than that of northern Europe, and Dr. Turrill indicates its importance as a centre of species-making and dispersal, especially with regard to the ancient land-mass, the old core of the Peninsula, centred in the Rodope massif.

The illustrations include a folding map and a few photographic reproductions of the vegetation. The book is very clearly printed, but the distribution of the margins on the pages suggests that the text has slipped bodily towards the top and the effect is not pleasing.

A. B. R.

Our Bookshelf.

The Concise Oxford Dictionary of Current English. Adapted by H. W. Fowler and F. G. Fowler from *The Oxford Dictionary*. New edition, revised by H. W. Fowler. Pp. xv + 1444. (Oxford: Clarendon Press; London: Oxford University Press, 1929.) 7*s.* 6*d.* net.

THIS is so far the best of the smaller and cheaper English dictionaries that comparison seems almost ludicrous. We have a book of nearly 1500 pages, well printed and stoutly bound, for seven and sixpence. Simply as a book, it must be the cheapest thing now on the market. But the contents deserve a close examination, and increase at every step our admiration.

The book is based on the great "Oxford Dictionary" which alone made it possible. The first edition, which was published in 1911, was compiled when the great book had only reached the letter R. At that time the Fowlers, who are responsible for this smaller work, drew for the later letters on Skeat, the "Century", and other standard books then extant. The completion of the O.E.D. has now enabled Mr. H. W. Fowler, who is alone responsible for this new edition, to revise in the light of the latest authority. He has produced a dictionary which will probably become the handy daily book of reference for everyone who writes, and is quite sufficient for ordinary educational purposes. It contains more than forty thousand words, and abundant phrases illustrating their use. These are not quotations from named sources; for that one has to refer to the original work. But they are specially chosen to exhibit the language as a living thing. They are, in fact, rather colloquial and current than literary, and this is why the book will have its great vogue and serve to build up as well as restrain the growth of English in the rising generation. It will be used side by side with the same author's "Modern English Usage".

Testing the dictionary here and there on scientific words, we find that it contains more than any other of like size and scope, but that preference is given to words deriving from the older established sciences, especially mathematics, over newer words arising, say, from biology. Quite a sound and useful definition is given of 'integral', 'differential', 'potential', but nothing of 'dominant', 'recessive', etc., in the Mendelian sense. This is mentioned not so much as a fault as to indicate the sort of line that has been taken. The book is a marvel of cheapness, compression, and good judgment on the lines indicated by its source and its purpose. F. S. M.

Elementary Laboratory Experiments in Organic Chemistry. By Prof. Roger Adams and Prof. John R. Johnson. Pp. xi + 304. (New York: The Macmillan Co., 1928.) 8*s.*

THE authors describe this book as a "laboratory manual designed for first semester students in organic chemistry". It offers a carefully planned series of practical exercises permitting of combinations to suit various circumstances. Examples of operations illustrating the general principles of purification, etc., are followed by some forty representative preparations. Many of the latter are naturally 'hardy annuals', but we notice the introduction of *n*-butyl alcohol in an instructive sequence of operations leading up to *n*-valeric acid. Noteworthy also is the 'subjective' synthesis by the student, *in vivo*, of hippuric acid.

The experimental details and precautions are exactly stated throughout and are quite up-to-date: thus, acetaldehyde is prepared by depolymerising paraldehyde, and valuable hints—too often omitted—are given in the accounts of acetamide and acetanilide. The authors suggest that the inclusion of such details as the amounts of washing and drying agents to be used may arouse criticism; but probably most experienced teachers will agree that it is almost impossible to be too precise in initiating students into a correct laboratory routine in this subject. The emphasis laid in the foreword upon accuracy and neatness is also very necessary. A useful appendix contains tables of densities, etc., and also summaries of the materials and time required for each experiment. It should be mentioned that the work does not comprise the identification of organic substances.

The book is economically but adequately illustrated, and it is well printed on a good paper which should withstand ordinary laboratory wear. The leaves are perforated and printed on one side only, so that the experimental sheets may be detached as required; incidentally, the blank pages are reckoned in the pagination. The volume can be confidently recommended as an excellent medium for effecting the introduction of students to the practice of organic chemistry. J. R.

Section de Géodésie de l'Union Géodésique et Géophysique internationale. Publication spéciale No. 2: *Tables de l'Ellipsoïde de Référence international adopté par l'Assemblée générale de Madrid le 7 octobre 1924 dans le système de la Division sexagésimale de la Circonférence.* Calculées sous la direction du Général G. Perrier par E. Hasse. Pp. 20 + 91. (Paris: Union Géodésique et Géophysique internationale, 1928.)

THE Section of Geodesy of the International Union of Geodesy and Geophysics decided at its 1924 meeting, in Madrid, to adopt an international ellipsoid of reference for geodetic measurements, and chose Hayford's ellipsoid, with the ellipticity 1/297·0 and major semi-axis 6378·388 km. as its primary elements. The secretariat was charged to publish tables of reference for this ellipsoid both for the sexagesimal and centesimal measures of angle: the present volume fulfils the first of these tasks. The tables, printed from typewritten sheets, are legible, well arranged, and well bound, as befits a work of reference. They give, to ten decimal places, for each minute of latitude, the logarithms of N, ρ and $\sqrt{N\rho}$, where N is the principal normal or radius of curvature of a meridian section, and ρ is the other principal radius of curvature; also, to six decimals, the logarithm of the factor of spherical

excess, the length of 1′ arcs of parallels to 0·01 mm., and, to 1 mm., the lengths of meridian arcs from the equator to each minute of latitude.

Physik: ein Lehrbuch für Studierende an den Universitäten und technischen Hochschulen. Von Prof. Wilhelm H. Westphal. Pp. xvi + 536. (Berlin: Julius Springer, 1928.) 18 gold marks.

PROF. WESTPHAL'S book is intended to be an elementary outline of physics, based upon our modern views of the structure of matter, and it is obviously based upon considerable teaching experience. It deals mainly with what we should term rather advanced intermediate physics, and the author introduces sections on entropy, the Nernst heat theorem, the electron theory of conduction, the ratio of the electrical units, thermomagnetic phenomena, the Zeeman effect and black body radiation, which are not usually found in English intermediate text-books of physics. The chapters on the quantum theory and the theory of matter and on the theory of relativity would certainly not be found in English intermediate text-books. These chapters are, of course, designed for beginners, and the former chapter even includes sections on wave mechanics and on the recent work of Sommerfeld on the electron theory of metals. The book is exceedingly well written and well illustrated. It is a book which a teacher may well recommend to an advanced intermediate student who wishes to study German.

The Science of Flight: Aeroplanes, Seaplanes and Aero Engines. By Capt. P. H. Sumner. Pp. xv + 292. (London: Crosby Lockwood and Son, 1928.) 25*s.* net.

Two years ago, Capt. Sumner published the first of his two volumes on "The Science of Flight and its Practical Application", in which he confined his attention to the development of airships and kite balloons, the scientific principles involved, and the construction and equipment of such machines. This second volume completes the review of the subject, and though his descriptions refer almost entirely to work done in Great Britain, there is a short historical chapter dealing with the early work of Lilienthal, Langley, Orville and Wilbur Wright, and other pioneers, and also with some of the memorable flights of recent years.

One chapter is devoted to the principles of aerodynamics, another to the airscrew, another to the general construction of aircraft, and a fourth to aeronautical instruments. A chapter on petrol engines in general is followed by descriptions and particulars of such famous engines as the Bristol Jupiter, the series of Armstrong Siddeley engines, the Napier Lion engine, the Rolls Royce and other engines, and the dimensions and performances of many well-known machines are included.

The People of the Twilight. By Diamond Jenness. Pp. x + 247 + 16 plates. (New York: The Macmillan Co., 1928.) 12*s.* 6*d.* net.

MR. JENNESS, as a member of the Canadian Arctic Expedition of 1913–18, spent two years with the Eskimo around Coronation Gulf. His headquarters were Bernard Harbour, and he made long visits to the little-known trade station in the south-west of Victoria Island. In these visits he cut himself off from the habits of the white man and lived the life of the Eskimo. The result is one of the most intimate studies of Eskimo habits and ways of life that has yet been published. He writes well, with sympathy for his friends and a real understanding of their problems. Although the book is meant for popular reading, it is one of the most valuable works on Eskimo life that has yet appeared. It adds much also to our knowledge of the natural history of the Canadian Arctic.

Einleitung in die Mengenlehre. Von Prof. Dr. Adolf Fraenkel. (Die Grundlehren der mathematischen Wissenschaften in Einzeldarstellungen mit besonderer Berücksichtigung der Anwendungsgebiete, herausgegeben von R. Courant, Band 9.) Dritte umgearbeitete und stark erweiterte Auflage. Pp. xiv + 424. (Berlin: Julius Springer, 1928.) 22·60 gold marks.

THE theory of aggregates is a very difficult subject, on the border line between mathematics and philosophy, and many questions of the first importance are still unsettled. Indeed, it may be said that the subject is more unsettled now than when Prof. Fraenkel first published his book (1919). In this, the third edition, revised and considerably enlarged, he has endeavoured to give an impartial account of different views, including those of Russell and Whitehead, which until recently have been too little known in Germany. Finally, the author sums up and gives his own personal views, but modestly mentions that these may have to be modified in the near future. Prof. Fraenkel's book appears to be one of the clearest expositions available of an extremely abstract branch of science.

H. T. H. P.

Feelings and Emotions: the Wittenberg Symposium. By Alfred Adler, F. Aveling, Vladimir M. Bekhterev, Madison Bentley, G. S. Brett, Karl Bühler, Walter B. Cannon, Harvey A. Carr, Ed. Claparède, Knight Dunlap, Robert H. Gault, D. Werner Gruehn, L. B. Hoisington, D. T. Howard, Erich Jaensch, Pierre Janet, Joseph Jastrow, Carl Jörgensen, David Katz, F. Kiesow, F. Krueger, Herbert S. Langfeld, William McDougall, Henri Piéron, W. B. Pillsbury, Morton Prince, Carl E. Seashore, Charles E. Spearman, Wilhelm Stern, George M. Stratton, John S. Terry, Margaret F. Washburn, Albert P. Weiss, Robert S. Woodworth. Edited by Martin L. Reymert. (The International University Series in Psychology.) Pp. xvi + 453. (Worcester, Mass.: Clark University Press; London: Oxford University Press, 1928.) 28*s.* net.

THIS volume forms a handy means of reference to some of the more characteristic views of several distinguished psychologists. The papers, thirty-four in number, were delivered during a period of four days in the October of 1927 on the occasion of the inauguration of the new Psychological Laboratory at Wittenberg College, Springfield, Ohio.

Letters to the Editor.

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

East African Archæology.

IN view of the various references to the work of the East African Archæological Expedition which have appeared from time to time in the News and Views columns of NATURE during the past few months, and with special reference to Mr. E. J. Wayland's letter in the issue of April 20, p. 607, we would be grateful for the opportunity of briefly outlining our results and conclusions up-to-date.

While definitely holding that there is a direct correlation between the glacial phases of Europe and the Pluvials of the equatorial belt, we consider that in view of the divergencies of scientific opinion concerning the number and sequence of European glaciations, a complete correlation is at present premature.

Although preliminary work in the Nakuru-Elmenteita basin suggested that there had been five distinct wet periods (which we provisionally termed 0th, 1st, 2nd, and 3rd Pluvials, with a Post-pluvial wet phase) more detailed investigation in this and other basins has led to the conclusion that there are only two Pluvials of the first magnitude. The first of these is our original '0th Pluvial' and seems to have antedated much of the faulting in this part of the Great Rift Valley. The deposits of this Pluvial belong to the series which Prof. J. W. Gregory includes in his Nyasan series (see "The Rift Valley and Geology of East Africa", p. 171) which he dates —we think on insufficient evidence—as lower Miocene. The second major pluviation is subdivided by a dry period of only short duration and comprises our original 1st and 2nd Pluvials. At the close of this Pluvial there was a period of great aridity which was followed by a renewal of pluvial conditions for a short time. This is our original 3rd Pluvial. Another and still smaller wet period is recorded by a fresh rise in the lakes at a comparatively recent date.

In order to avoid the use of ordinals in referring to the Pluvial periods, we have proposed the following nomenclature for the Pluvial periods which we have so far recognised :

Old Name.	*New Name.*
0th Pluvial.	Eburrian, 1st major Pluvial.
1st Pluvial.	Enderian } 2nd major
2nd Pluvial.	Gamblian } Pluvial.
3rd Pluvial.	Makalian.
Post-pluvial wet period.	Nakuran.

While avoiding for the present a more complete glacial-pluvial correlation, we suggest that our second major Pluvial—the Enderio-Gamblian—can be correlated with the Würm (or Riss and Würm) glaciations, or preferably with the 'Newer Drift' of northern Europe. We agree with Mr. Wayland in regarding the Makalian as probably the equivalent of the Bühl stadium. Many implementiferous horizons have been established in the Pluvial deposits and we append a table setting out the relation of the various cultures to the changes of climate. In view of the great similarity of certain of our cultures to those of Europe, we have ventured to employ the accepted European terminology while *emphasising* that by so doing we do not in any way suggest that the cultures in Kenya were necessarily contemporaneous with their European homologues. A large mammalian fauna has been collected from the deposits of the various Pluvials with the exception of the Eburrian, but pending investigation by a competent specialist, it is impossible to use them for correlation purposes.

Period.	Culture.
Nakuran	Contemporary: (*a*) A culture which is comparable to the Wilton of South Africa. (*b*) A culture which consists of a degenerate Aurignacian type of tool associated with pottery, agriculture, and also beads of a type which suggest a contact with one of the early civilisations. (Human type, Nakuru man.)
Makalian	A specialised form of Aurignacian culture associated with pottery. (Human type, Elmenteita man.)
Gamblian : (2) Closing stages	Contemporary: (*a*) Upper Aurignacian. (*b*) Highly specialised Mousterian, probably due to Aurignacian influence.
(1) Rise and maximum.	Contemporary: (*a*) Lower Aurignacian gradually developing into Upper Aurignacian. (Human type, Gamble's cave man.) (*b*) Upper Mousterian with a marked tendency to trimming of both flake-surfaces towards the close of the period.
Enderian	Contemporary: (*a*) Crude lower Aurignacian. (*b*) Lower Mousterian.
Eburrian-Enderian Interpluvial.	A single culture comprising large degenerate forms of ovate, very small, well-made *coups-de-poing* and flake tools with a distinct Mousterian tendency.
Eburrian : (2) Closing stages	A very fine Acheulean industry with the *S*-twist a common feature.
(1) Rise and maximum.	?

L. S. B. LEAKEY (Leader).
J. D. SOLOMON (Geologist).

East African Archæological Expedition,
P.O. Elmenteita, Kenya,
May 29.

The Problem of Form in Physics and Biology.

IT is not unusual to hear statements that a characteristic feature of physical phenomena, as opposed to the phenomena of life, is that the form does not play any part at all in the former, and that therefore "of all problems of physiology, that of form is the least approachable" (O. Warburg, *J. Cancer Research*, **1**, 143; 1925: quoted from V. Cofman, *Chem. Rev.*, December 1928). Without intending at all to participate in any way in the much-debated question as to the ultimate reducibility of life phenomena to those of physics and chemistry, may I point here to certain purely physical cases which, if even not yet entirely realised experimentally, are at least conceivable, and in which the form plays a very essential part.

If we consider physico-chemical systems in the state of equilibrium, the question as to the part played by the form reduces to the following: Does the free energy (or entropy, or any other thermodynamic function, the extremum of which determines the equilibrium) of the system depend on the form of the latter or not? So long as we consider systems with a small specific surface, in which the surface energy is negligible as compared with the volume energy, the answer is negative. Keeping the internal chemical constitution constant, we may alter the form of the system in any arbitrary way without changing its free energy. The form, therefore, is not a characteristic property of such a system.

If, however, we consider systems with large specific surface, in which the surface energy plays a predominant part, the situation changes. Take the trivial case of a homogeneous drop, not subject to gravity. It necessarily assumes a spherical shape, for the smaller the surface area the smaller the free energy of the system, and since the surface area depends on the shape, so does also the free energy. Of course, with the spherical form alone, there is not much done. We must therefore ask: Is the spherical form the only form of equilibrium for a free liquid system with large specific surface, and not subjected to gravity? In this connexion it may be of interest to mention (cf. my paper in *Zeitschrift für Physik*, **51**, 571; 1928) that if we consider a small droplet of any liquid, in which are dissolved several capillary active substances, we must consider such a droplet as consisting of *two* phases; one volume phase, and one 'monomolecular' two-dimensional surface phase, formed by the adsorbtion of the capillary active substances. In the general case, when the two phases may interact reversibly, it may be shown that, for a given volume V of the droplet, the total free energy of the system has a minimum for a certain definite area S_0 of the surface, which may happen to be larger than the area of surface of a sphere of the same volume ($\sqrt[3]{36\pi V^2}$). The droplet in this case assumes *any arbitary shape*, within certain limits, for then there is an infinite number of shapes, for which a body of a given volume has a prescribed surface area. The remark "within certain limits" is important. If, for example, the surface area corresponding to the equilibrium is only slightly larger than the surface area of a sphere of the same volume, then the system, though not being spherical, cannot assume, say, a form of an uniform thin long thread, for this would make S_0 too large (cf. my paper on "Systems with Large Specific Surface" in *Zeitschrift für Physik*, **53**, 107; 1929).

The most interesting cases, however, where the equilibrium of a liquid system is associated with a *definite* form, are found in investigating the possibility of interaction of such a droplet with the surrounding medium. Imagine the interior of the droplet to be the seat of chemical reactions, which result in the formation of the substances, of which the drop consists, from those substances which are dissolved in the surrounding medium. These latter, assuming their solubility in the main substance of the droplet, will in these circumstances diffuse from outside into the drop, and will be 'absorbed' there, due to the chemical transformations. If the increase of the total mass of the droplet is very slow, we have the case of a quasi-stationary diffusion process, in which the amount of substances diffusing into the droplet approximately equals the amount absorbed. There is in this case a concentration gradient of these substances from the periphery to the interior of the droplet, and the distribution of the concentrations depends on the instantaneous form of the droplet. The concentration of the dissolved substances will vary along the surface of the droplet, and since the surface tension is a function of the concentrations of the dissolved substances, the surface tension will also vary along the surface. But it is possible that for a certain form of the droplet the distribution of the concentrations along the surface will be such that for all points of the surface the product of the surface tension with the mean curvature of the surface will have the same value. The corresponding form, which is itself determined by the functional relation between surface tension and concentration, and may vary widely from case to case, will be a form of equilibrium and will be automatically restored, if disturbed by a temporary external cause. The details of the mathematical treatment will appear in *Zeitschrift für Physik*.

N. RASHEVSKY.
Research Department,
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May 14.

The Mobility of Ions in Gases.

IN a recent paper (*Phil. Mag.*, **6**, 210; July 1928) I described a new method of determining the mobility of ions in gases, the principle employed being the same as that originated by Fizeau for the determination of the velocity of light. It is the purpose of the present note to describe an improvement in the previous method, giving a marked increase in both resolving power and absolute accuracy. This is obtained by the introduction of a new type of grid for producing the periodic 'shutter effect' of Fizeau.

An account of preliminary experiments with the new type of grid, which may be called a deflection grid, was given by me in a D.Phil. thesis in May 1928. In the abstract of this thesis (Abstracts of Dissertations, vol. 1, p. 126; Clarendon Press, Oxford, 1928) the work on the new type of grid was referred to. Recently the same type of grid has been described independently by Cravath (*Phys. Rev.*, **33**, 605; April 1929), who used it for a purpose other than the determination of mobilities.

The deflection grid consists of a series of closely spaced parallel bars or wires lying in the same plane. Alternate bars are connected to one outside electrode, and the remaining bars are likewise connected to a second outside electrode. Thus a slight potential difference between these two electrodes stops the passage through the grid of ions or electrons in the gas by deflecting them to the bars, whereas with no potential difference the grid is identical with one of the usual type.

A typical peak obtained by this method of mobility determination is given in Fig. 1, which shows the electrometer current as a function of the time elapsing

between the momentary 'opening' of the first grid (or shutter) and the momentary 'opening' of the second grid. As the periodic change of potential across the deflection grids was effected by a commutator of known speed and dimensions, a curve showing the theoretical resolving power may be easily constructed. This theoretical curve is shown dotted in Fig. 1. The close approximation of the experimental to the theoretical curve shows that the method has in practice a high resolving power, and also that,

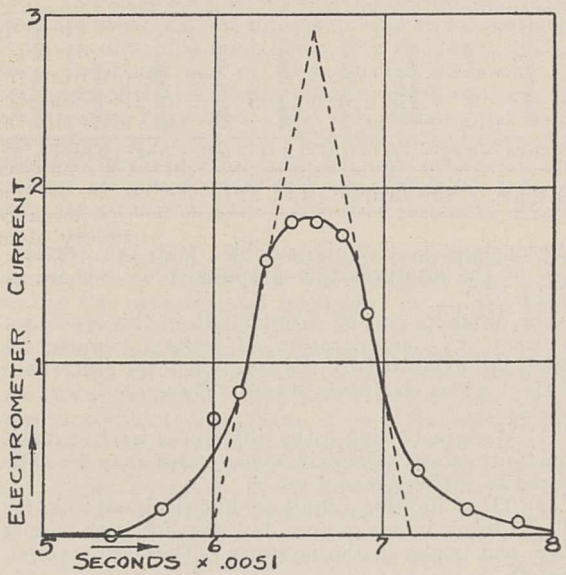

FIG. 1.

at least within narrow limits, all the ions had the same mobility, which is 1·84 cm. per sec. as computed from the curve. The experiments were carried out in moist air at atmospheric pressure, and the initial ionisation was obtained by the action of ultra-violet light on a zinc plate.

Grids for these experiments may be conveniently constructed by first grinding a series of parallel slots in a thin glass plate, then completely silvering the surface of the glass, and finally scraping off the silver where insulation is desired.

R. J. VAN DE GRAAFF
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Oxford.

Influence of Temperature on Raman Lines.

IN a letter to NATURE of Oct. 27, 1928, on the influence of temperature on the modified lines in scattered light, Dr. Krishnan reported that with rising temperature the intensity of the anti-Stokes lines was increased relative to that of the Stokes lines, using carbon tetrachloride as the scattering substance. I have examined also the influence of temperature on certain organic liquids and have observed an effect of another kind. When the temperature of the scattering substance is increased, certain Raman lines become very diffuse. Fig. 1 shows the Raman spectrum scattered by toluene at 10° C. and at 100° C., the light source being a mercury lamp. Nearly all the lines which appear in this figure are modified from the strong Hg line, 4359, except 4617·89 and 4589·2, which are modified from the Hg line 4047. Among them it can be seen that the doublet lines $\lambda = 4686{\cdot}82$ and 4683·33 ($\Delta\nu$ from 4359 being 1607·2 cm.$^{-1}$ and 1591·7 cm.$^{-1}$ respectively) become very diffuse at the high temperature. Fig. 2 shows the photomicrometric curve of that spectrum, in which noticeably affected lines are indicated by arrows. The same effect is observed in the scattering by other substances for example, benzene and carbon tetrachloride.

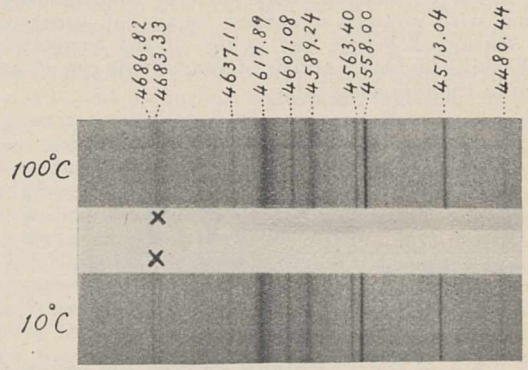

FIG. 1.

Since this broadening of the lines is not common to every line, it does not seem natural to attribute it to the Doppler effect. At all temperatures it is easily noticed with fairly large dispersion that the Raman lines caused by organic substances have several types of structure, that is, very sharp, symmetrically diffuse, asymmetrically diffuse, etc. Also, the broadening effect of temperature is, generally speaking, more noticeable on diffuse lines than on sharp lines. From these facts it does not seem unnatural to suppose that the diffuseness of Raman lines

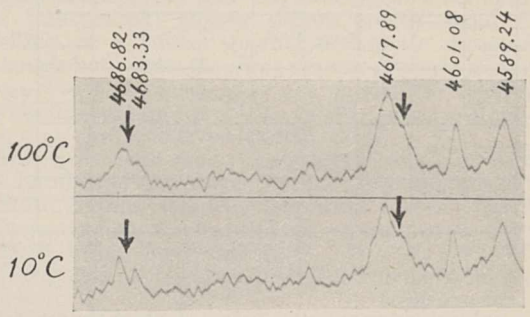

FIG. 2.

is due to molecular rotation and that the increase of temperature accelerates the rotation and causes the broadening of the lines. Further, it is interesting to notice here that in the Raman spectrum of organic substances there very often appear close doublets, and that the influence of temperature is most noticeable upon them. The above-mentioned toluene lines are one example; the doublet in benzene, 4687·10 and 4681·93 ($\Delta\nu = 1680{\cdot}9$ and 1584·4), is another example.

Y. FUJIOKA.
The Institute of Physical and
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Hongō, Tokyo, April 15.

Sunspots and Pressure.

IN Bombay (Colaba) magnetic data, 1846–1905, Part II. (page 751), Dr. N. A. F. Moos shows that if the annual means of atmospheric pressure at Bombay are smoothed by taking overlapping means of 11 successive years, and if the smoothed 11-year means are placed at the proper epoch, the resulting variation appears to be subject to some slow period secular

change which runs fairly concurrently with that noted in the magnetic and solar curves similarly treated. I was Dr. Moos's assistant at Bombay in 1910 when the volumes were published. As time permitted I tried the 11-year smoothing process on other stations and found correlation coefficients of the smoothed means with similar smoothed means of sunspots. The stations selected, the values of the correlation coefficients, and the number of years made use of, are given in the following table :

	Tokyo.	Batavia.	Port Darwin.	Calcutta.	Madras.	Bombay.	Eniseisk.	Greenwich.	Abbassia (Cairo).	Cape Town.	Mauritius.	Charleston.	Santiago.	Cordoba.	Buenos Aires.
Correlation coefficient .	−0·65	−0·59	−0·61	−0·61	−0·27	−0·37	+0·03	−0·23	−0·61	−0·63	+0·14	+0·10	+0·32	+0·50	+0·73
No. of years . . .	47	55	43	55	55	55	50	55	52	55	50	52	55	52	55

At 6 out of the 15 stations selected the values of the correlation coefficients exceed 0·6, and the positive relationship at the South American stations is significant.

In *Indian Meteorological Memoirs*, Vol. 21, Part XII, published in 1915, on sunspots and pressure, by Sir Gilbert Walker, correlation coefficients between the annual means of sunspots and pressure are given for some 90 stations over the globe. There are only

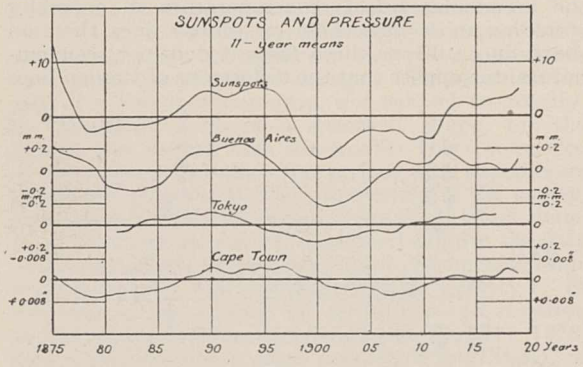


FIG. 1.

three values rising above 0·4, in two of which the number of years is only 20 or 22. The largest value, − 0·47, is for Cape Town record for 55 years.

It is probable that irregularities due to various causes mask the relationship from year to year, and the 11-year smoothing process may be fruitful in leading one to the true nature of the relationship.

Curves for sunspots and for pressure at three significant stations are charted in the accompanying diagram (Fig. 1) for exhibiting the parallelism. The period embraces 5 sunspot cycles. The amplitude of the pressure range is about 0·4 mm.

M. V. UNAKAR.

Meteorological Office, Poona,
May 17.

Properties of the He_2 Rotation Terms.

THE analysis of the band spectrum of helium is now nearly complete. The great majority of the stronger lines have been allocated to bands, of which some sixty have now been recognised. The remaining lines may be attributed to (1) higher members of the electronic sequences already known, (2) electronic levels of a new type, and (3) vibrational levels.

In connexion with (1) a special difficulty arises, apart from the relative faintness of the lines, in that most of the bands suffer very considerable changes as the principal electronic quantum number, n, increases. Not only may the appearance of a branch entirely change (from R to Q, say), but it may fade out entirely. In some cases a band which has all three branches present for $n = 3$ is reduced to a single branch (R, but of P-form) when $n = 6$. The usual method of procedure, by searching for combination relationships, is then impossible, and the correctness of the interpretation proposed must remain in doubt.

The difficulty can be surmounted, in this spectrum at least, by consideration of certain regularities which are exhibited by the rotation term differences of the various electronic states. These are briefly as follows :

(1) With increasing n the differences tend to reach constant values, which in many cases may be estimated to within about 1 cm.$^{-1}$.

(2) These limiting values are identical, not only for all the terms in one system, but also for both singlet (par) and triplet (ortho) systems. They are approximately

	71	127	183	239	294	347	399	450 cm.$^{-1}$
for $(j-\rho)=$	2	4	6	8	10	12	14	16

These are evidently the rotation term differences of the He_2^+ ion, and correspond to odd values of $(j-\rho)$, the even values being missing, in agreement with theory.

(3) The ρ values associated with each electronic state follow at once from the above data, and agree throughout with those proposed by Dieke (NATURE, vol. 123, p. 716, 1929), except that for his p_b states $\rho = +1$ instead of -1 as given in his table.

It is unnecessary to give here a full description of the regularities found, but they are such that most of the rotation terms at present missing can be predicted within a few cm.$^{-1}$; conversely, the interpretation of new bands is greatly facilitated. Thus, for example, two new branches of P- and Q-form recently found by Dieke, Takamine, and Imanishi (*Zeitschr. f. Phys.*, **54**, 826 ; 1929), but not identified, are easily recognisable by this method as Q and R branches of the $6X$ level of ortho-He_2. Even single branches may now be interpreted, provided that the final electronic state is known, since it is possible to derive a set of initial term differences by combining the known final term differences with the intervals between successive lines in the branch. These differences, if genuine, will fit into the scheme and their designation will be apparent.

It is clear that this method will be of very great assistance in resolving the last complexities of the He_2 spectrum. It will be interesting to see whether it is applicable to other band spectra, and in particular to that of hydrogen.

W. E. CURTIS.
A. HARVEY.

Armstrong College,
Newcastle-upon-Tyne,
May 31.

The Heterodyne Null Method of Measuring Dielectric Constant.

IT is found that different investigators using the same heterodyne null method differ widely in their results for the same substance. This is indicated from the results of different investigators in the cases of carbon dioxide, hydrogen sulphide, and methyl chloride. In a recent paper (*Phys. Rev.*, **32**; 1928) Zahn has tried to find out the sources of this discrepancy, and suggests that besides the calibration errors there are other possible sources of error in the method. From the data of Watson (*Proc. Roy. Soc.*, **117**; 1927), Zahn attributes one of these to the difference in frequency of the oscillating circuits which the various investigators have used. But this cannot produce a large effect on the results. We wish to point out the possible sources of error from our own experience for the last couple of years with the apparatus we are using for measurements of dielectric constant. They are as follows:

(1) The method of measuring temperature by winding the platinum wire on the glass tube containing the experimental condenser or on the condenser itself (when a cylindrical condenser is used) with proper insulation, may probably produce a large error owing to the presence of this stray capacity near the experimental condenser if proper care is not taken to eliminate this effect. Even if the bath which contains the experimental condenser is well earthed, still this stray capacity affects the results, and proper care should be taken to connect the experimental condenser in the case of a cylindrical one. This effect has been carefully studied by Sarkar (*Ind. Jour. Phys.*, **3**; 1928). He found that when the inner cylinder of the experimental condenser was connected to the anode of the thermionic tube it gave more concordant results than when the outer cylinder was connected. In the latter case even the movement of any other conductor or variation of current in any other circuit connected to the mains in the room would change the pitch of the beat note, whereas no such difficulty was observed in the former case.

Hence the method of measuring the temperature by the thermo-couple is preferable. It is also found that when the thermo-couple is put into the bath the frequency of the oscillating circuit changes. It is therefore advisable not to put the thermo-couple into the bath at the time of taking observations, and the temperature should be measured just before and after the observations are taken.

(2) If the bath be heated electrically from the mains, it is found that there is a difference of pitch when there is no current passing through the heating coil and when there is a current passing. This evidently indicates a presence of stray capacity and induction effect. To avoid this, it is better to disconnect the heating coil of the bath from the main when the measurement is to be taken.

Taking all these precautions we have found that the value of the dielectric constant for dry and carbon dioxide free air at N.T.P., is $1{\cdot}000579_{\pm 4}$.

P. N. GHOSH.
P. C. MAHANTI.
University College of Science and Technology, Calcutta.

The Swelling of Rubber.

SOME recent experiments on the diminution of the vapour pressure of solvents in rubber jellies as well as measurements of swelling pressure allow us to draw some conclusions as to the nature of the swelling phenomenon.

It has been found that, at the same concentration of rubber, the vapour pressure of rubber jellies from rubber of *different* origin was the same, and previous mechanical working (mastication) of rubber had also no effect on this value (P. Stamberger, *Rec. Trav. Chim. Pays-Bas.*, **47**, 316; 1928). After the mechanical working, however, the rubber swells in an unlimited manner and gives as a resulting product up to a concentration of 30 per cent a more or less viscous liquid. This behaviour shows that the solvent is not bound by surface adsorption and that there is a great resemblance to the process of molecular disperse solution. The three solvents used for these determinations were: carbon disulphide, chloroform, and benzene. The *same relative vapour pressure diminution* was found when the concentration has been calculated as grams of rubber in 1 gm. mol. solvent.

The shape of the curve in which the relative vapour pressure was plotted against the concentration differs from that expected according to Raoult's laws. The curves bend rapidly at a concentration of 20-30 per cent towards the vapour pressure axis. Although some resemblance to the ordinary process of solution was found, this behaviour suggests a process of a more complicated nature. But the affinity of the solvent for the rubber can only be due to molecular forces.

Although no difference has been found between the vapour pressure of the 'liquid' jelly of masticated rubber and the solid elastic jelly of untreated rubber, the swelling pressure of both showed *big differences*.

The liquid, masticated rubber jelly had a swelling pressure of 35 cm. of mercury at a concentration of 0·4 gm. rubber in 1 c.c. of solvent (toluene), the unmasticated had the same swelling pressure at a much lower concentration, 0·11 gm./c.c.

This value shows that the swelling of a structureless (masticated) rubber differs greatly from the swelling of a rubber having a definite structure, although both show the same vapour pressure diminution. For this reason it is not possible to calculate the swelling pressure from the vapour pressure diminution on a simple thermodynamic basis.

This behaviour shows that the forces which cause the imbibition of solvent by the jelly are not of a uniform nature and the 'structure factor' has an influence when the solvent is present in a liquid form (P. Stamberger, loc. cit.).

Particulars of this investigation will be published shortly.

P. STAMBERGER.
C. M. BLOW.
University College, London,
June 4.

The Isotopes of Oxygen.

I HAVE recently been studying the vibrational energy functions of molecules, in connexion with a recalculation of heats of dissociation, and have noticed that the equation given by Dieke and Babcock (*Proc. Nat. Acad. Sci.*, **13**, 670; 1927) for the upper level of the atmospheric bands of oxygen has an unusually large coefficient for the n^3 term. This, I now find, is due to an arithmetical error of 2 cm.$^{-1}$ in their location of the origin of the $O - O$ band. The correct figure should be 13,120·97 cm.$^{-1}$, instead of their 13,122·97. The correction not only leads to the expected small coefficient for n^3, but also brings their data into good agreement with the older constants, as given on p. 232 of the "Report on Molecular Spectra in Gases". The resulting corrected equation is

$$E_n = 13{,}120{\cdot}97 + 1418{\cdot}69n - 13{\cdot}925n^2 - 0{\cdot}02n^3$$
$$(n = 0,\ 1,\ 2,\ 3),$$

as contrasted with their

$$E_n = 13{,}122{\cdot}965 + 1415{\cdot}017n - 11{\cdot}911n^2 - 0{\cdot}3525n^3$$

The new constants are of importance in connexion with the isotopes of oxygen. Giauque and Johnston

(NATURE, Mar. 2, 1929) found that the assumption of $O^{16} - O^{18}$ and $O^{16} - O^{16}$ as the two molecules concerned, led to a calculated isotope splitting, in the $O - O$ band, which averaged 0·05 cm.$^{-1}$ greater than the observed splitting. (From their original data I find that the average is 0·053 cm.$^{-1}$, for the 25 lines used.) The change in the vibrational constants just given lowers the calculated splitting by just 0·067 cm.$^{-1}$, making the discrepancy now only 0·014 cm.$^{-1}$ in the opposite direction.

More recently, Giauque and Johnston (NATURE, June 1, 1929) have interpreted faint lines in the $O - O$ band, newly found by H. D. Babcock (*Proc. Nat. Acad. Sci.*, in press), as due to an $O^{16} - O^{17}$ molecule. The calculated isotope splitting is again too large, in this case by an average of 0·03 cm.$^{-1}$, although the faintness of the new lines makes the probable error much larger than in the previous case. The change in vibrational constants lowers the calculated splitting 0·036 cm.$^{-1}$, and so practically cancels the discrepancy. One can accordingly conclude that there is now perfect agreement with the theory, on the basis of 16, 17, and 18 for the atomic weights, and half-integers (on the *old* quantum theory) for the vibrational quantum numbers.

Babcock's measurements of relative intensity (NATURE, May 18, 1929) indicate that O^{16} has an abundance at least 1250 times that of O^{18} (see Giauque and Johnston, NATURE, June 1, 1929). The O^{17} atom, according to Babcock's work, is much less abundant than O^{18}. On the basis of these figures, Aston's determinations of atomic weights, made with his mass spectrograph, should be not more than one part in 10,000 greater than the chemical values.

RAYMOND T. BIRGE.

University of California, June 1.

An Intermetallic Compound having a Simple Cubic Lattice.

ANTIMONY tin alloys [1] containing 43, 50, and 55 per cent of antimony were annealed respectively at temperatures of 240°, 270°, 290°, in a closed glass tube for 200 hours, then slowly cooled to 240° and kept

FIG. 1.

25 hours at this temperature, and by slow cooling brought to room temperature. These samples showed the X-ray spectrum lines belonging to a simple cubic lattice, as shown in the accompanying photogram (Fig. 1). The table below indicates the result of the X-ray analysis.

FILM-DIAMETER = 5·525 CM., RADIATION FROM IRON.

Indices.	43 per Cent Antimony (Rod).		55 per Cent Antimony (Rod).		50 per Cent Antimony (Powder).	
	Reflected Angle.	Lattice Constant.	Reflected Angle.	Lattice Constant.	Reflected Angle.	Lattice Constant.
(100)	18·29°	3·052 A.	18·40°	3·065 A.	18·39°	3·068 A.
(110)	26·67	3·049	26·65	3·051	26·50	3·066
(111)	33·34	3·050	33·34	3·050	33·12	2·067
(200)	39·39	3·050	39·39	3·050	39·31	3·054
(210)	45·16	3·051	45·11	3·053	44·91	3·064
(220)	63·69	3·053	63·46	3·059	63·69	3·053
{221} {300}	71·86	3·054	71·89	3·054	71·95	3·053
	Mean . 3·052 A.		Mean . 3·054 A.		Mean . 3·061 A.	

[1] The equilibrium diagram of this system studied by Prof. K. Iwasé and N. Aoki will appear in *Science Reports* of Tôhoku Imperial University, Sendai.

The densities observed for 43, 50, and 55 per cent antimony are respectively 6·9084, 6·9100, 6·9109. The number of atoms contained in a unit cell is calculated to be 0·9918, 0·9993, and 0·9908, being very nearly equal to 1. This fact and the spectral indices confirm that the crystal structure of these alloys is a simple cubic lattice. From the result of the X-ray analysis it is concluded that the range lying between 43 and 55 per cent of antimony is a solid solution of this compound and one of the components. It is only very rarely that a metallic compound has a simple cubic lattice.

ATOMI ÔSAWA.

Imperial University, Sendai.

Heterogonic Growth in the Appendages of Crustacea.

PROF. J. S. HUXLEY and Miss Tazelaar find (NATURE June 15, p. 910) that the appendages behind the enlarged male chela in *Inachus* and *Palæmon carcinus* show a slight acceleration of growth, while those anterior to it show a slight retardation. They express this as " an influence on the growth gradient by the axial relations of the whole animal ". I presume that this is merely a way of expressing a purely empirical correlation, and therefore I do not understand what is meant by suggestions bearing on the mechanism of this influence. What is the mechanism of the influence which produces the original heterogonic growth centre near the tip of the large chela ?

Empirically the heterogonic growth of the large chela is correlated with greater muscular activity on the part of this chela in the male as compared with the female. It seems to me the important question is whether the acceleration of growth in appendages posterior to the chela is correlated with greater activity of those appendages as compared with those anterior to the chela. As for ' mechanism ', it is generally agreed that the heterogonic growth in the individual crustacean is due to some endocrine effect associated with the male gonad or with the sex-chromosomes. Surely whatever the mechanism may be which causes the heterogonic growth of the large chela, that of the appendages posterior to it is due to the same mechanism. I see no reason for assuming that the accelerated growth of the latter is a secondary effect of that of the large chela.

J. T. CUNNINGHAM.

35 Wavendon Avenue, W.4.

Hermaphrodite Oysters.

THE interesting question of hermaphrodite oysters was raised in NATURE of June 8 by Mr. I. Amemiya.

On this subject it is appropriate to make the following remarks :

1. In 1854, Lacaze-Duthiers (*Ann. Sci. nat. Zool.*, ser. 4, ii., p. 217) pointed out the hermaphroditism of the small *Ostrea stentina* Payr., synonymous with *O. plicatula* Gmel. and *O. plicata* Chemn., for malacologists generally.

2. In 1911 an undeterminable *Ostrea* (*O. sp.*) from Saleh Bay (Sumbawa) was quoted as hermaphroditic (" Siboga Expedit.", Part 53 *a*, pp. 27 and 102).

3. In 1926, Gutsel (*Science*, **44**, p. 450) described the hermaphroditism of *Ostrea equestris*.

4. With *O. edulis*, *O. angasi*, *O. lurida* and *O. densela-mellosa*, there are, so far, only seven hermaphroditic species in the great genus *Ostrea*, or a very small number in comparison with the dioïc forms in the same genus. The latter are very numerous indeed : namely, all the species of the ' subgenera ' *Alectryonia* and *Gryphœa*, and also some others which are not related to these two groups.

PAUL PELSENEER.

The Distribution of the Chemical Elements.[1]

By Dr. V. M. GOLDSCHMIDT, Professor of Mineralogy, Oslo.

PETROLOGISTS generally agree that the earth contains a core of an iron alloy, most probably nickel iron with about 8 per cent of nickel, in analogy to the most common types of iron meteorites. Below the common silicate rocks of the crust there is probably a region of enrichment of heavier silicates, which have separated by crystallisation from molten silicate magma, and have settled downward owing to their high specific gravity. Probably the mineral olivine is present here in substantially larger amounts than in the average surface rocks. Concerning the physical state of matter in this heavier silicate shell underlying the earth's crust, we know with certainty that it is in the solid state, and that certain crystallised silicates and other minerals must be present in a peculiar state of high density owing to pressure, which is characteristic for the eclogite facies, as deduced by Fermor and Eskola, and recently most convincingly demonstrated by P. Wagner.

Between the eclogite shell and the iron core there is still another mighty shell, separated from the eclogite shell and from the iron core by surfaces of discontinuity detected by measurements of the propagation of seismic waves. By many petrologists this shell is considered to be a mixture of silicate and nickel iron. This opinion, however, does not explain the fact that there seems to be a very distinct boundary to the iron core, and also a marked discontinuity against the silicate mantle. It seems also improbable that two substances of so different density as iron and silicate, originally present in a molten state, would not have separated in the earth's field of gravity. The possibility must be considered that this intermediate shell largely, or at least to a considerable part, contains sulphides and oxides of heavy metals, especially the monosulphide of iron, a substance we even observe as a distinct separate phase in a very large number of meteorites.

From many basic igneous rocks in the earth's crust molten sulphides segregate as separate sulphide magmas. Any such sulphide magma will tend to migrate towards the zone between the iron core and the silicate mantle, so that in this region of the interior of the earth there would accumulate the major part of sulphidic compounds, mainly iron monosulphide, together with heavy oxidic minerals, especially oxides of iron and chromium, which separate from silicate magmas at early stages of crystallisation.

Outside the silicate shell or lithosphere, there are further envelopes of our earth, the hydrosphere and the atmosphere, and on the boundary between the lithosphere and atmosphere, as well as intergrown through the hydrosphere, there is a

Radial Thickness.	Density.	Name.	Main Chemical Features.	Main Physical Features.	Which Group of Elements is Concentrated.
Several 100 km.	0-0·0015	Atmosphere	Nitrogen, oxygen, water vapour, carbon dioxide, rare gases	Gas	Atmophile
0-11 km.	about 1	Biosphere	Organic substances and skeleton minerals	Solid and liquid, often in colloidal division	Biophile
0-11 km.	1	Hydrosphere	Oceanic and fresh water with dissolved salts and gases, snow and ice	Liquid (in part solid)	Atmophile (and some lithophile)
60-120 km.	2·8	Earth's crust of silicates	Ordinary silicate rocks	Solid	Lithophile (of late crystallisations and mother liquors)
1100 km.	3·6-4	Eclogite shell	Silicate rocks, probably rich in Mg_2SiO_4	Solid, very dense crystalline arrangements of atoms (eclogite facies)	Lithophile (of early crystallisations)
1700 km.	5-6	Sulphide - oxide shell	Characterised by large amounts of sulphides and oxides of heavy metals, especially iron	Solid	Chalkophile
3500 km.	8-10	Nickel iron core	Alloy of iron and nickel	Solid (in part liquid ?)	Siderophile

[1] From a discourse delivered at the Royal Institution on Friday, Mar. 15.

last, and from the human point of view a most important sphere, the biosphere, the zone of organised organic substance, the zone of life.

Our earth thus is separated into a number of shells, arranged in the order of density, as shown by the table on p. 15.

Men of science agree that our solid earth must once have been in a molten condition to enable the density distribution which prevails to-day to be formed. Already in times older than geological record, in the early 'astronomical' age of the earth, the subdivision of the molten planet, surrounded by a gaseous envelope, into several liquids, must have begun, followed by separation of the different liquid phases according to gravity. The distribution of chemical elements between the three liquids and one gaseous phase may now be considered from the viewpoint of physical chemistry; we may try to find the quotients of partition in the four-phase equilibrium. Such volatile elements, which have no very great affinity to the substances of the three liquid phases, will accumulate in the gaseous envelope, such as, for example, argon and nitrogen; also compounds with similar properties, as water and carbonic acid, will enter the primordial atmosphere. All these substances may be called *atmophile*. Many chemical elements gather in the silicate magma; they are *lithophile* elements. The most prominent element is oxygen, constituting 62 per cent of the numbers of atoms present, or even 92 per cent of the volume of the earth's crust. The only heavy metal entering in appreciable amounts into the silicate shell is iron, about 2 atomic per cent of iron being present.

Next we shall consider the elements which are concentrated in the molten iron; we may call them *siderophile* elements. These are elements having a great solubility in molten iron, either as uncombined elements or as chemical compounds, such as nickel, platinum, carbon, phosphorus. Lastly, we may consider the elements which enter into molten iron sulphide; we may give them the name *chalcophile* elements. Such elements are, for example, copper, silver, lead, bismuth, selenium.

The actual amount of metals and of non-metallic elements in the earth as a whole has resulted in sulphuration and oxidation of part of the iron. We find iron in large amounts in the sulphide phase, and even to some extent in the silicate phase. Therefore, the partition of all other metals will be dependent on their affinities to oxygen and to sulphur, compared with those of iron. If an element is more siderophile than iron it will enter into the nickel-iron core; if it is more chalcophile than iron it will concentrate in the sulphide phase; if its inclination to enter into oxygen compounds is greater than that of iron it will accumulate in the silicate slag. Iron, therefore, is a kind of measure of geochemical affinity.

It would be interesting to know whether the rarity of precious metals is real, or if it is due to special quotients of partition which might have concentrated such metals as gold and the platinum metals, in the interior of our planet. Especially it would be a matter of importance to ascertain if the elements of the platinum group really are so very rare as they appear to be from most analysis of terrestrial matter. The average amount of platinum in the average silicate rocks may be considered to be of the order of 1 to 1000 millions, that is, about 1 gram in 1000 tons of rock. We may, without any doubt, predict that platinum and the other siderophile metals of the platinum group must be found in very much larger concentrations in iron meteorites, if the present distribution of elements is due to an equilibrium of partition. By the microdocimastic methods of analysis, worked out for our geochemical work by Dr. Lunde and Mrs. Johnson Høst, a large number of terrestrial rocks and of meteorites were analysed for precious metals by Mrs. Høst in my laboratory. Some data from her determinations illustrate the amount of platinum metals in meteorites:

Iron Meteorites.	Total Platinum Metals.
Arispe	117 grams per ton.
Savik, Cape York	75
Mount Joy	68, 54
Mukerop	38
Toluca	25
N'Goureyma	2, 2

Silicate Meteorites.

Juvinas	No platinum metals, no silver, no gold. Total precious metals less than 0·05 gm. per ton.
Stannern	No platinum metals, no silver, no gold. Total precious metals less than 0·05 gm. per ton.

These data, and many others, demonstrate that the platinum metals are not to be considered as very rare elements, but that their relative rarity in terrestrial surface rocks is only a consequence of their partition between nickel iron and silicates.

The quotients of partition between the different phases for any given element must be dependent on the properties of this element, and we may expect to find general relations between geochemical distribution and the properties of atoms and ions. If we plot a diagram showing the atomic volume of the chemical elements as a function of atomic number (nuclear charge), we find the following correlation between geochemical character and atomic volume. The typical siderophile elements are found at the minima of atomic volume, as, for example, carbon, phosphorus, iron, ruthenium, platinum. The typical atmophile elements tend towards the maxima of atomic volume, such as hydrogen and the rare gases. Lithophile elements occupy the descending branches, where we find the typical ion-forming elements such as magnesium and calcium. In the ascending branches of the curve we find the typical chalcophile elements, for example, copper and selenium. These regularities seem to be connected with different types of electronic arrangement in the several types of atoms and ions. If there exist elements following after uranium in atomic number, they are probably siderophile, and for this reason they may be absent or nearly absent from the rocks of the earth's crust.

We have seen how the present distribution and

apparent frequency of chemical elements may be largely due to the laws of partition between the four phases, a separation which has taken place in the very early history of our earth. As cooling proceeds there comes into action a new kind of separation, which has no precedents in the earlier history of our earth, namely, *fractional crystallisation*. Among the first products of separation are minerals with low solubility in the silicate magma and high melting points, such as chromite and olivine; then follow other iron ores, together with the bulk of pyroxenes and plagioclase felspars; later on the pyroxenes are succeeded by amphiboles and biotite; and the basic plagioclases are followed by acid ones and by potash felspar, with quartz and muscovite. At last only pegmatitic magmas and aqueous solutions remain as a kind of mother liquor of the magma, from which crystallise coarse pegmatitic dikes and hydrothermal mineral veins, and from which also gaseous constituents may escape, giving rise to pneumatolytical minerals.

Whilst the partition into atmophile, lithophile, etc., groups had taken place between amorphous phases, as gases and liquids, the process of fractional crystallisation involves the presence of crystalline phases, and the properties of atoms and ions in crystalline arrangements must be of deciding importance for the fate of the different elements. The distribution of any given element between a liquid phase and a coexisting crystalline phase will depend on isomorphism between the element (or its ions) with the components of the crystalline phase. Now isomorphism, as crystallographers have known for a very long time, is mainly dependent on the volume of the different kinds of atoms or ions, and the question of partition therefore leads to a relation between atomic and ionic sizes and geochemical distribution. Therefore, from the geochemical point of view, it is most important to get exact determinations of the radii of atoms and ions in crystals. The formation of crystals will effect a sieving or sorting of elements, and this process of sieving may determine the fate of any rarer element present, including both lithophile elements and the small amounts of siderophile and chalcophile elements which have entered the molten silicate.

We must also consider the very important case that the rare element does not enter the crystal, but is forced to remain in the liquid. In this manner a number of rare elements are concentrated in the mother liquors of magmas. There they remain until their concentration reaches the saturation limit of their own crystalline phases; then they are precipitated as minerals of rare elements. This explains why, in the mother liquors of silicate magmas, the pegmatite magmas, we encounter such a wealth of rare elements. If our principle concerning the relation between fractional crystallisation and the sizes of atoms and ions is sound, we shall expect to find *two very different types* of rare elements in the mother liquors: those which are of *very small* size compared with current atomic and ionic sizes, and those which have *very large* sizes. This is in the very best accordance with mineralogical experience.

The specific gravity of the liquid part of an ordinary silicate magma, which undergoes processes of fractional crystallisation, decreases substantially as crystallisation proceeds, owing to the high density of the earlier minerals and to the increase in volatile components (as water and carbonic acid) in the mother liquor. Residual magmas and associated aqueous solution will thus have a strong tendency to migrate upwards to the uppermost levels of the earth's crust, and heavy minerals of early crystallisation will tend to sink down towards deep levels. Therefore, in the highest levels of the silicate shell we encounter a relative enrichment of those elements that are concentrated in the light granitic rocks and residual solutions of the magmatic sequence. For this reason many of the rare elements, which are typical for pegmatitic associations, are found in comparatively high concentrations in the uppermost levels of the atmosphere.

The fact that chemists have been able to detect not less than 89 out of 92 possible elements is surely due to the circumstance that the processes of distribution, acting in a strong field of gravitation, have been very favourable for accumulating even very rare lithophile elements in considerable amounts near the surface of our earth. Also, the distribution of the radioactive elements, with a marked enrichment of uranium and thorium in the light rocks of very high levels, is in complete accordance with the principles of geochemical distribution.

An investigation of the present distribution of chemical elements, however, cannot be limited to the study of inorganic nature; there is at work one more factor—the youngest in the story of geochemical evolution—that is, the organic world, the *biosphere* of the earth. Living organisms need a number of elements for the construction of protoplasm and auxiliary substances; we may mention carbon, hydrogen, oxygen, phosphorus, sulphur, chlorine, together with small but indispensable amounts of rarer elements such as iodine. Under most varying conditions of life, organisms have shown their ability to concentrate and utilise the different types of necessary substances; they have become one of the important factors regulating the distribution of chemical elements. Especially for such elements which in the original inorganic matter are present only in more modest concentrations, such as phosphorus or iodine, or fixed nitrogen, organic Nature has become a dominating factor of distribution.

We may become conscious of the importance of organic life in geochemistry if we consider that our present atmosphere, containing a large amount of oxygen and only traces of carbon dioxide, may have got these features largely through the action of plant life on the primary atmosphere of our planet. We may particularly refer, in this connexion, to the ever-increasing activity of man in utilising the resources of our earth, thereby greatly altering the distribution of elements within the reach of his power.

The North-East Coast Exhibition at Newcastle-upon-Tyne.

THIS is an exhibition with a purpose; it is the gallant attempt of a depressed area to help itself. The genesis of the idea was inside the Chamber of Commerce on Newcastle Quayside; afterwards it was taken up by the Lord Mayor and Corporation; it has been carried through by the leaders of industry working as citizens in committees under a general council representative of the associated cities. The idea is the quest for business through associated advertisement and salesmanship.

The Exhibition is in a corner of the Town Moor behind the Hancock Natural History Museum and about a mile from the Central Station. It is easily accessible by tram. Turning round for a moment before entering the gates, Armstrong College and its new Mining Department are seen 300 yards away. Just inside the Exhibition turnstiles a kiosk supplies an "Official Guide" (price 3*d*.) with a plan of the main buildings. These include Palaces of Engineering, Industries, and Arts, a Festival Hall for conferences, a Stadium for boy scouts, an Amusements Park, and the sideshows of the evening newspapers. An "Official Catalogue" (price 1*s*.), bought before leaving and studied at home, will save time on a second visit. This contains the names and portraits of the organisers, a list of exhibits, plans, and full indices. It is a very handy volume, indicative of excellent general organisation. A more bulky "Exhibition Year Supplement" of the *Newcastle and Gateshead Chamber of Commerce Journal* (price 2*s*. 6*d*.), is obtainable in the Guildhall on the Quayside. It contains a trade index of industries with illustrated advertisements. It seems valuable for strangers intending to place large orders or inquiring into the industrial environment before choosing sites for new works.

The natural products of the area include not only coal but also whinstone and limestone for road-making, freestone for building, grindstones from the millstone grit, lime from both carboniferous and magnesian limestones, magnesia from the latter, fireclay from beneath the coal, brick-clay from nearer the surface, brine from the trias, and iron-stone from the oolite. Navigable estuaries admit shipping and encourage shipbuilding, deep river gorges have stimulated the bridge builders, Cleveland iron-stone and Durham coal have made the Middlesboro' iron and steel industry which supplies material for all the engineering works. Tyneside was the birthplace of Stephenson and of the locomotive. More lately the district has been to the front in the production of high tension electric supply in alternators driven by Parsons turbine machinery, and this electric current has been applied to railway traction and through a grid for other industrial purposes.

The greatest engineering triumphs will not fit into exhibitions. The new Tyne Bridge with roadway slung from an arch apparently parabolic is seen when entering Newcastle from the south. The *Mauretania* and its floating dock may be seen at Southampton. The latest colliery improvements are in the collieries and at work. Locomotives and rolling stock are on the railways. Within the Palace of Engineering these greater objects can only be represented by pictures and models; 30 tons has been the limit, a steam rail coach brought in by the London and North-Eastern Railway Company. A few other exhibits are here named as samples, not as a catalogue.

Sir Howard Grubb, Parsons and Co., show a reflecting telescope of 3-feet aperture intended for the Royal Observatory, Edinburgh. It is designed in accordance with specifications by Prof. R. A. Sampson, and is to be used chiefly for spectroscopic work. The parabolic mirror and auxiliary hyperbolic mirror combine to make an equivalent focal length of 54 feet. The driving circle is clamped to the polar axis by hydraulic pressure. The driving clock has both its own frictional governor and also a control by impulses received every second from an observatory timekeeper.

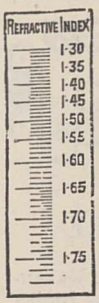
Messrs. Reyrolle and Co. have specialised on switch-gear for large electric power stations. With voltages of 33,000 the contacts are made and broken under oil and inside earthed metal-clad cases.

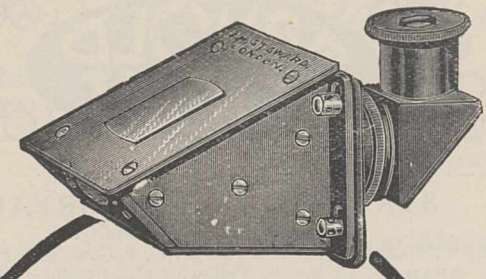
Imperial Chemical Industries explain, by means of a cinema hall, what their associated companies are doing at Billingham. Pictures show how the fertilisers make the grass grow in intensive culture paddocks. Specimens of various products are shown, Billingham carbonate of lime, nitro-chalk and imported nitro-phoska, chlorine for water purification, Portland cement, etc.

The Thermal Syndicate is an example of a new industry made possible by electric supply. Its 'vitreosil' or fused silica finds increasing applications due to its high melting point, low coefficient of expansion, transparency to ultra-violet light, non-conduction of electricity and resistance to acid. The size of worm-tubes for condensation has greatly increased. Also for laboratory use is the Pyrex glass made in Sunderland. There are numerous domestic electrical appliances for heating and cooking. The Electric Lamp Manufacturers' Association is advising on the best methods of industrial lighting.

Among recent developments of driving machinery are the Diesel and half-Diesel engines. A new Doxford engine has no closed ends to its cylinders but two pistons both moving outwards. The great production of metal work has been a stimulus to paint, enamel, and anti-fouling compositions. A coke maker is using X-rays to detect unseen impurities. A toffee-making machine, automatic with endless band, attracts attention. But it is not only the toffee and the toffee-making machine that matter. Behind it stands the maker of the toffee-making machine, and the possibility of inventing other machines with continuous output at increasing profits for other industries. Unfortunately, unlike a toffee works, a coal-mine exhausts its product; it cannot expand indefinitely, it must finance its sinking funds on other principles. This and other

(*Continued on p.* 27.)





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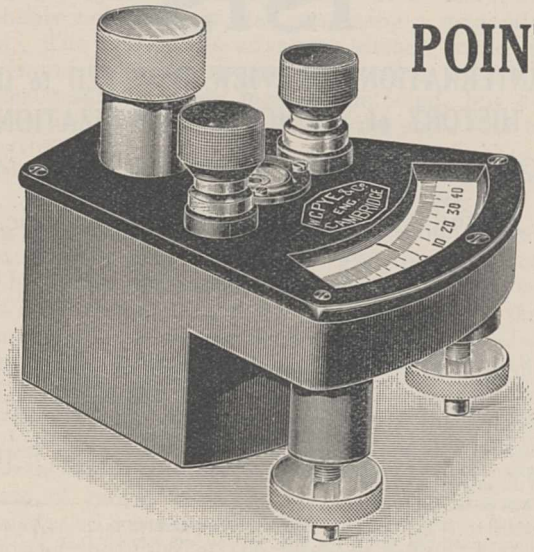

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Cosmical Magnetic Phenomena.[1]

By Prof. S. CHAPMAN, F.R.S.

MAGNETISM on a grand scale in the cosmos has been observed only on the sun and the earth. The earth's magnetism has been studied for more than three centuries; Gilbert's treatise on it, published in 1600, was the first book on modern experimental science, and his recognition that the earth is a great magnet preceded Newton's discovery of universal gravitation. Solar magnetism was first detected twenty-one years ago,[2] and all our knowledge of it comes from a single observatory.

The measurement of the sun's magnetic field is indirect. It depends on the influence, called the Zeeman effect, which the field exerts on atoms emitting or absorbing light. Certain lines in the solar spectrum are split up, or broadened, by an amount which indicates the magnetic intensity at the sun's surface. From this it is easy to calculate the maximum possible intensity of the sun's magnetic field near the earth, and to show that it is too small to be measured directly.

The sun is intrinsically a typical star, though its planetary system is exceptional. It is therefore probably not the only star possessing a magnetic field. The marvellous advances already made in astronomical technique give hope that, in time, stellar magnetic fields may be detected, but at present the measurement of even the sun's field is very difficult.

Lunar and Planetary Magnetism.

It is natural to inquire whether the moon and planets have magnetic fields. The moon is not self-luminous, and has no absorbing atmosphere, so that indirect detection of its field by means of the Zeeman effect is not possible. It is doubtful also whether the Zeeman effect will be measurable on any of the planets. Hence, unless we can measure *directly* the lunar and planetary fields in the earth's neighbourhood, they are likely to remain unknown.[3] Now the field-intensity near the earth, due to a sphere of radius a at distance d, with average intensity of magnetisation I, is $\frac{4}{3}\pi I(a/d^3)$. This varies as the cube of the angular radius of the sphere (a/d), as viewed from the earth. The moon, which has a much larger angular radius than any planet, is therefore the body most likely to exert a measurable magnetic force near the earth. A weak external field would be difficult to disentangle from the earth's field, if it were uniform and constant, but the moon's field would be neither of these. It would reveal itself in two ways: owing to the varying distance of the moon as it moves in its rather eccentric orbit, there would be a *monthly* magnetic variation, while the earth's rotation in the slightly non-uniform lunar field would produce a lunar *daily* magnetic variation.

Lunar periodicities in the earth's magnetism have been minutely studied; a lunar *daily* magnetic variation does occur, but it is an indirect effect of the tidal action of the moon on the earth's atmosphere. No variation of the type which a lunar magnetic field would produce directly has been found; if the intensity of the field near the earth were so great as 10^{-4} gauss (or 10γ) it would scarcely have escaped notice. This indicates that for the moon the value of I cannot exceed 100; for the earth I is 0·1, and a value for the moon 1000 times as large as this was in any case scarcely to be expected;[4] in other words, the failure to detect the moon's field near the earth was *a priori* likely. The same applies still more strongly to the planets, and though planetary periodicities in the earth's magnetism have been sought for, none has ever been found.

Cosmical magnetic phenomena, as actually observed, are therefore either terrestrial or solar. Their study demands, first of all, accurate, detailed and long-continued measurements. Then the observations must be reduced by systematic analysis to a much smaller ordered body of facts. This process involves great labour, and is still incomplete, even in the case of the earth. Some important features of the phenomena can be readily perceived, but others have been found only by long computations and minute comparisons with related phenomena. The final task is to explain the facts in terms of general physical laws; this has proved very difficult, and most of the problems of cosmical magnetism remain unsolved. Mathematics is essential in the theoretical discussion; the large scale of the phenomena almost always precludes an experimental test of proposed hypotheses; their consequences, which must be compared with observation, can only be calculated.

Terrestrial Magnetism.

While the study of the sun's magnetism is still in its infancy, terrestrial magnetic science has a

[1] Rouse Ball Lecture delivered at Cambridge on May 31.

[2] By Hale at Mount Wilson, California.

[3] There is a faint possibility that they may be detected by their deflecting influence on streams of charged particles which issue from the sun and afterwards fall on the earth.

[4] The magnetic intensity at the surface of a sphere is proportional to I, and if I for the moon were 100, the intensity of its field at its poles would be about 800 gauss, or more than ten times the intensity of the sun's magnetic field.

long history. Seamen, clockmakers, explorers and others have gradually accumulated the great store of data that we now possess; these have been charted and analysed by numerous workers, and have provoked a long series of theoretical speculations. During the Middle Ages the directive property of the compass was generally ascribed to an influence proceeding from the heavens, sometimes even from a particular star; but in the year 1600 William Gilbert, of Colchester and St. John's College, Cambridge, showed that the cause is terrestrial. His proof was simple and convincing; he took a spherical piece of loadstone and explored its field by means of small pivoted magnets; they set themselves in relation to the sphere just as compass needles do in relation to the earth, showing the observed distribution of magnetic dip (Fig. 1); hence he inferred that the earth itself is a great magnet. He had the good fortune to be dealing with one of the few physical properties of a large globe like the earth that can be easily illustrated by a small model.

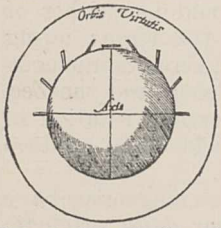

FIG. 1.—Reproduction of a woodcut from Gilbert's "De Magnete" (English translation, 1900).

Subsequent observations have shown that the compass direction can depart more widely from the true north than Gilbert supposed. The earth's field does nearly resemble that of a spherical magnet, but the magnetic axis is inclined at about 12° to the axis of rotation. In addition, the field is complicated by many irregularities, which, however, do not obscure its main features.

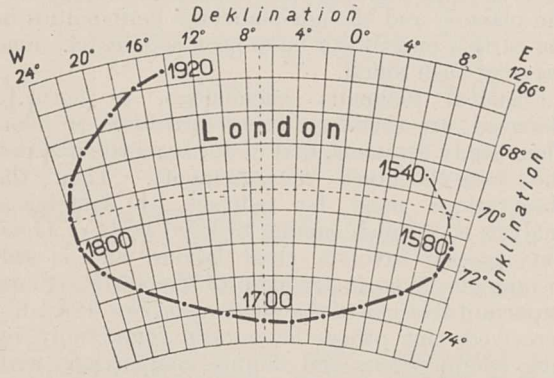

FIG. 2.—Variation of the magnetic declination and inclination at London since 1540, in spherical projection. (After Bauer.) From "Erdmagnetismus, Erdstrom und Polarlicht", by J. Bartels (Gutenberg's "Lehrbuch der Geophysik").

Soon after Gilbert's death, it was found that the earth's field is not constant. The secular change in the *direction* of the magnetic force has been measured at a few places for more than three centuries, but the data for the first two of these are scanty. Measurements of the *intensity* of the field extend over little more than a century. The change in the direction of the force at London since 1540 is shown in Fig. 2; the variation appears to be fairly regular, and possibly periodic; if so, the period is not less than five centuries. It has been supposed that the secular variation largely consists of a rotation of the earth's magnetic axis round its axis of rotation, but the observations do not warrant this inference (cf. Fig. 3). They suggest rather that the secular variation, though a large-scale phenomenon, is regional and not world-wide in character. Its most notable property is its rapidity: large-scale changes in the state of the earth are in general much slower than the magnetic variation. The earth's magnetisation seems to have decreased by about 5 per cent during the century for which observations of the intensity are available; at present the decrease is proceeding most rapidly in the southern hemisphere (cf. Fig. 4).

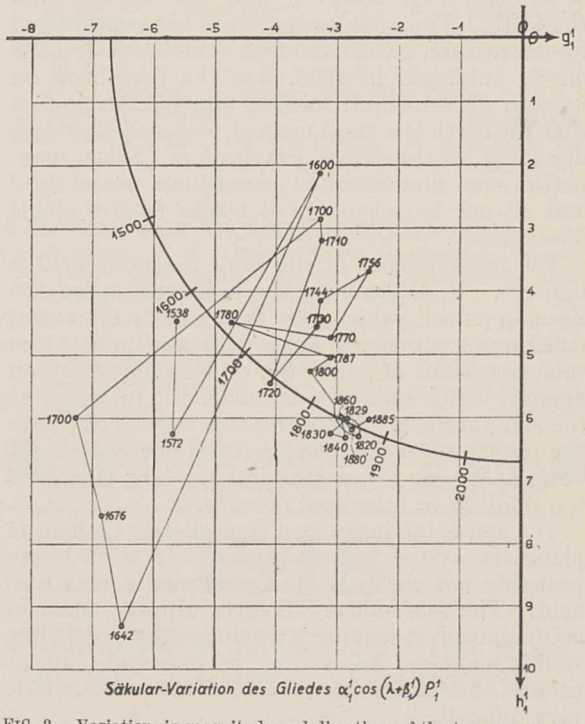

FIG. 3.—Variation, in magnitude and direction, of the transverse component of the earth's magnetism, which mainly determines the obliquity of the magnetic axis. The determinations before 1820 are very uncertain, and the subsequent change in direction of the axis is small.

On the basis of our present knowledge, it is impossible to guess the past or predict the future course of the earth's magnetism. Three centuries is a trivial fraction of the life of the earth, and workers on terrestrial magnetism may envy astronomers, whose observations extend over thousands of years. Geologists, who have the age-long record of the rocks at their disposal, are still more fortunate. There is hope, however, that the rocks may reveal also something of the *magnetic* history of the earth.

Just before volcanic lava solidifies, it acquires induced magnetism along the direction of the earth's field; afterwards its magnetism is believed to remain constant. Mercanton, of Switzerland, has determined the direction of magnetisation of lava specimens carefully cut out from deposits, in many parts of the earth, which appear not to have been tilted or distorted since they were first formed. He

therefore infers the direction of the earth's field, relative to the lava deposits, at remote geological epochs. Large deviations from the existing relative direction of the field are found, the difference sometimes almost amounting to a reversal. Can the earth's magnetism really have changed its sign during geological time? One is tempted to say

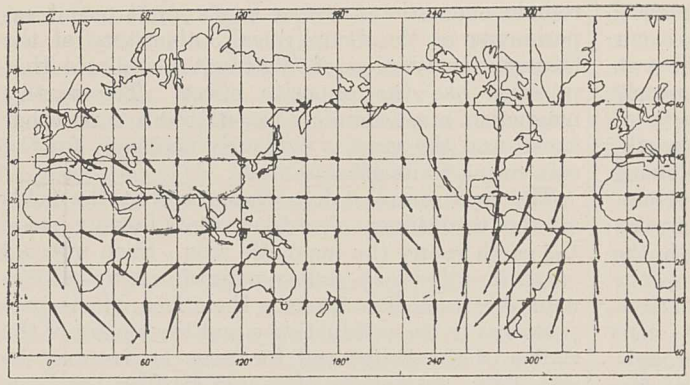

FIG. 4.—Annual secular variation of horizontal magnetic force at epoch 1922 (after Bartels): scale 200γ per cm. (approximately).

no, but the denial is unjustified while we know so little about the cause of the magnetic field. Other interpretations of the evidence may, however, be possible; though the lava may not have been tilted or distorted, it may have moved or turned bodily, in a horizontal plane, relative to the field. If the possibility of such motion can be excluded, or if the motion can be estimated, our knowledge of the earth's magnetic history may be greatly extended.

Gilbert's comparison of the earth with a spherical loadstone gave a concise representation of a multitude of isolated magnetic measurements. It could not establish a physical theory of the earth's magnetism, but it was the first contribution to the middle, systematic, stage in the development of terrestrial magnetic science. His demonstration of the internal origin of the field was confirmed and rendered more precise, 240 years later, by Gauss. In a memoir which, like Gilbert's treatise, marked an epoch in physical science, Gauss applied the theory of the potential, and the method of spherical harmonic analysis, to the earth's magnetism. He showed how from a knowledge of the distribution of magnetic force over the earth's surface it is possible to determine whether the origin of the field is internal or external, or both, and, in the latter case, how to evaluate the two separate parts. With the limited data at his disposal, he was content to show that the observations, including their departures from the field of a spherical magnet, were consistent with an internal origin. Later analyses, with better data, restrict any possible external part of the surface field to about 3 per cent of the whole; there may also be a similar small fraction which does not possess a potential, and is therefore due to electric currents *crossing* the surface, from earth to air or vice versa: but observations of atmospheric electricity cast doubt on the existence of this part.

The main fact is that the earth's field above its surface is similar to that outside Gilbert's spherical loadstone; the intensity at distance r from the earth's centre varies as $1/r^3$. When r is equal to two earth radii, that is, 4000 miles above the earth's surface, the field is reduced to one-eighth its surface value. Hence it remains appreciable for thousands of miles above the earth. The tubes of force extend throughout, and far beyond, the atmosphere.

Solar Magnetism.

The sun's field is quite different in this respect. It is fortunately possible to measure its intensity at different depths within the solar atmosphere, for the composition varies with depth, and the Zeeman effect can be determined independently from spectral lines due to different atoms at different levels. In this way Hale and his colleagues discovered a rapid decrease of magnetic intensity with increasing height. The measured reduction (from 50 to 10 gauss for the polar intensity) is in the ratio 5 to 1, and extends over a linear distance of only about 50 km., according to Milne's theory of the solar atmosphere. If the sun's field, like the earth's, varied in intensity as $1/r^3$, this 5 to 1 reduction would extend over more than a million kilometres.

The intensity probably diminishes to values still lower than 10 gauss, though these cannot yet be measured on the sun. The rapid radial decrease of the field shows that few or no tubes of magnetic force can pass through the sun's atmosphere into outer space; they must lie nearly horizontally in the atmosphere. The difference between the solar and terrestrial fields is illustrated by the lines of force outside the full circles in Fig. 5.

The sun's field, like the earth's, is nearly symmetrical about an axis, which in the solar case is inclined at about 4° to the axis of rotation. The

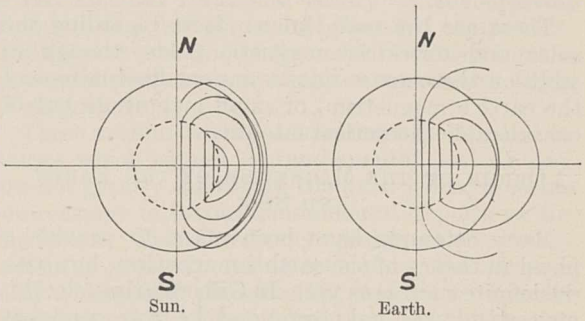

FIG. 5.—Lines of force in the solar and terrestrial magnetic fields: the curves inside the outer circles are merely conjectured.

magnetic polarity of the sun is the same, in relation to its direction of rotation, as for the earth—a fact of great theoretical interest. The earth's field, including its irregularities, rotates at the same speed as the nearly rigid earth, whereas the sun's field and magnetic axis rotate more slowly than the solar surface, the respective periods of rotation being about thirty-one days and twenty-six days.

The polar intensity of the earth's field is about $\frac{2}{3}$ of a gauss, while for the sun it is estimated to be 50 gauss; it may well be still greater lower down in the atmosphere, where the opacity of the gas prevents further observation.

In addition to the *general* field, there are very intense *local* magnetic fields in the sun's atmosphere, associated with sunspots: intensities of 3000 gauss are frequent; there is no corresponding terrestrial magnetic phenomenon. Sunspots commonly occur in pairs of opposite magnetic polarity; the two members of a pair generally lie along a line nearly parallel with the sun's equator. The polarity of the leading spots of pairs in one hemisphere (northern or southern) is the same as that of the following spots in the other hemisphere. The number of sunspots waxes and wanes in an eleven-year cycle: each cycle begins at sunspot minimum with the birth of spots in relatively high latitudes on the sun (about 30°); the spots are not of long continuance; as new spots appear and die away, their average latitude steadily decreases, both throughout the three or four years of increasing spot frequency, and in the subsequent seven or eight years after sunspot maximum, until the next epoch of minimum frequency is attained.

The cycle ends with the occasional appearance of spots near the solar equator; this continues for about a year after the beginning of a new cycle is marked by the recurrence of spots in high latitudes. All through the old cycle the leading spots in both hemispheres have a definite magnetic polarity, with few exceptions. In the new cycle the whole arrangement of polarities is reversed; the leading spots in both hemispheres have the polarity which in the preceding cycle characterised the leading spots in the other hemisphere. The complete cycle of sunspot change therefore extends over twenty-two years, and includes two maxima and two minima of sunspot frequency. A beautiful qualitative theory of this remarkable series of phenomena has been outlined by Bjerknes, and awaits quantitative development.

These are the main known facts regarding the solar and terrestrial magnetic fields, though in addition there are various transient fluctuations of the earth's magnetism, of small magnitude but of considerable theoretical interest.

Origin of the Magnetism of the Earth and Sun.

Many attempts have been made to provide a physical theory of the earth's magnetism, but with no definite success as yet. In Gilbert's time electromagnetism was unknown, and he was confident that the earth consists of magnetised matter, like his loadstones; he attributed the irregularities in the earth's field to the magnetic attraction of the continental and other inequalities of the earth's solid surface. A small, strongly magnetised, fraction of the globe, or a large part magnetised to a low intensity (0·1), would account for the field; but iron and other magnetic substances lose their magnetisability at critical temperatures which are attained at a small depth—20-30 km.—below the surface: there are various magnetic deposits in the layer above this depth, which are responsible for some notable local anomalies in the earth's field, but this layer seems quite insufficient to account for the main field. For a time it was hoped that the increase of pressure accompanying that of temperature as we go downward in the earth might raise the critical temperature, and so enable iron to remain magnetic at deeper levels; but recent experiments at the Geophysical Laboratory of the Carnegie Institution of Washington indicate that pressure has the opposite effect. The earth's magnetism must therefore be ascribed to some other cause, and the same is evidently necessary for the sun, owing to its gaseous state.

The next simplest hypothesis is that the fields are due to ordinary electric currents flowing inside the earth round the magnetic axis. Such internal currents will decay unless maintained by permanent electromotive forces; their free life is proportional to the conductivity and the square of the radius of the body, and for large bodies may be very long. In a globe of copper (at 0° C.) as large as the earth, the currents, as Lamb has shown, would take about 20 million years to decay in the ratio 10 to 1; while if the globe were as large as the sun, the time would be about two hundred thousand million years. I have recently estimated that the electrical conductivity at the centre of the sun is about 3×10^{-4}, half that of copper at ordinary temperatures, and that it decreases to about 10^{-8} just below the photosphere; large-scale electric currents in the sun would therefore die away at a rate imperceptible to us. The electrical conductivity of the earth is likely to be much less than that of copper, or even of iron (about 10^{-4}), at ordinary temperatures, because although iron possibly constitutes an important fraction of the core, its conductivity decreases considerably as the temperature rises; thus if *freely decaying* currents inside the earth are responsible for its magnetic field, their intensity in the remote past must have been immensely greater than now.

It must be left to future ages, by centuries of observation, to determine whether the fields of the sun and earth are decreasing; we cannot safely assume that the present rapid rate of diminution of the earth's field will continue. But there is no apparent reason why causes that could once generate such currents should altogether cease to operate, and the currents, if they exist, may be continuously maintained.

A possible mode of maintenance of internal electric currents has been suggested by Larmor; in the presence of the existing field, the necessary electromotive forces could be induced by an internal circulation having a component of its motion in the meridian planes, symmetrical about the axis and also with respect to the magnetic equator. Such a circulation might not only be able to *maintain* the electric current system and its magnetic fields: it might even build up the field from insignificant beginnings; and there is more than one known way in which the rotation could produce an initial field of very minute

intensity. The internal circulation, if once started, would decay very slowly, owing, as Lamb has shown, to the small influence of viscosity in large bodies; moreover, it might be maintained against frictional retardation at the expense of the heat energy of the body. In the sun, the motion of the mean sunspot zone towards the equator during each eleven-year cycle suggests the existence of a circulation of the right type; and such a circulation is invoked in Bjerknes' theory of sunspots, which, whatever its difficulties, is the only one that has yet shown any capacity to explain the remarkable collective properties of sunspots. I have applied a rough numerical test to Larmor's theory in the case of the sun, and the quantities involved seem not unreasonable; there are, however, some qualitative difficulties in the theory.

In the case of the earth, the existence of the supposed circulation is entirely conjectural, though if the underlying strata are slowly flowing equatorwards, and can exert a slight drag on the base of the continental masses, it might fit in with and remove a difficulty in theories of continental drift. Larmor has remarked also that the secular changes in the earth's magnetism might be simply accounted for merely by change of the conducting channels for the internal electric currents. The theory seems to me to have many attractive features, though until it is further developed, especially on the quantitative side, it must be viewed with reserve, like other geophysical or astrophysical theories in their first qualitative stages. Eddington has inferred from a theorem by von Zeipel that some kind of internal circulation must almost certainly arise in a rotating star; if it could be shown that the circulation is likely to be of the present type, Larmor's theory would gain further support, and would add weight to the conjecture, made many years ago by Schuster and Kelvin, that magnetic polarity is a general property of large rotating bodies.

A variety of other explanations of solar or terrestrial magnetism have been proposed, involving rotation as an essential feature. Those based solely on known facts and established physical laws have all failed to explain more than a minute fraction of the observed fields. Even the hypotheses in which some liberty of speculation has been taken have in most cases involved contradictions with observed facts of other kinds, which necessitate their rejection. Any simple theory which seeks to account for the observed intensities of the fields of the earth and sun in terms of their known density, size, and angular velocity must also be consistent with the observed failure of rotation, even at very considerable speeds, to produce magnetisation in non-magnetic bodies of small size in the laboratory; this proves to be a rather stringent limitation.

Among the theories which satisfy this condition and are based on some hitherto unrecognised fundamental property of matter, the most recondite is that due to Swann. He modified the electromagnetic equations slightly, by the addition of small terms depending not only on v, the velocity of the electric charge, as in the classical theory, but also on $\dot{v}$ and $\ddot{v}$. His additional terms are such that no new effects arise merely through uniform *translation* of matter; that is, the equations remain invariant under the transformation of the restricted theory of relativity. The terms contain a factor, the form of which is chosen so that in the case of uniform *rotation* of neutral matter, with angular velocity ω, they imply the existence of a current density proportional to $\omega^4 r^3$, at distance r from the axis; this law of variation of the hypothetical current density was shown by Swann to be the only suitable simple law that will give magnetic fields of the right relative magnitude for the sun and the earth,[5] and a very small field for rotating bodies in the laboratory. Finally, by appropriate choice of a numerical constant involved in the new terms, the theory is made to fit the actual magnitudes of the solar and terrestrial fields. The whole procedure is elaborately *ad hoc*, and therefore somewhat unattractive, despite the skill with which the theory is developed. While the modified equations fulfil their intended purpose without appearing to introduce discrepancies with other observed facts, only one new consequence was inferred from them, namely, that small, rapidly rotating non-magnetic bodies should have a minute but just measurable field. Swann and Longacre have recently succeeded in testing this prediction, which is found to fail.

On the whole, it seems to me unlikely that cosmical magnetism has any fundamental significance in physics, involving, as in Swann's theory, small modifications in the general laws, which reveal themselves only in rotating bodies of great size. Any such hypothesis leads to a field symmetrical about the axis of rotation, whereas neither the sun's nor the earth's field is of this type; the obliquity of the magnetic to the rotational axis is about 4° for the sun, and about 12° for the earth. Thus the transverse component of the field, which a fundamental rotational theory cannot explain, amounts to a few per cent of the axial component. The secular variation of the earth's field is a further non-axial phenomenon of the same relative order of magnitude.

These asymmetrical features must be ascribed to causes which cannot be fundamental, and as they are not greatly inferior to the axial fields, it seems unnecessary to invoke fundamental hypotheses for the latter. Therefore in my opinion cosmical magnetism is probably only a secondary, though possibly widespread, phenomenon, and not a universal fundamental one like gravitation. If this be so, theories of cosmical magnetism must involve factors of an accidental character, not too rigorously determined *a priori*, in order that they may account for the varied secondary features of the solar and terrestrial magnetic fields. In this respect Larmor's semi-hydrodynamical theory seems preferable to hypotheses like Swann's.

[5] Owing to the uncertainty as to the true maximum intensity of the magnetic field of the sun, it is unsafe to attach much importance to the observed ratio of the solar and terrestrial intensities.

The Electrical Conductivity within the Earth.

Though the cause of the earth's magnetism and its secular variation is still uncertain, the study of these phenomena is likely in time to add materially to our knowledge of the earth's interior. At present our knowledge of this region is derived mainly from quite different lines of evidence; every fresh sidelight on this *terra incognita* is worth the most careful attention. The secular variation suggests that, despite the mechanical stability of the earth, fairly rapid changes are proceeding within it, and that the interior is much more mobile than the outer layers: when the variation has been observed over a longer period, detailed inferences as to the nature of the internal changes should become possible. Already, however, terrestrial magnetism has provided one definite fact regarding the earth's interior, which could scarcely have been obtained otherwise; hitherto no use has been made of it in theories of the constitution of the earth, and perhaps laboratory experiments are required before this will be feasible, but the fact must sooner or later be taken into account.

If a conducting body be placed in a varying magnetic field, electric currents will be induced in it; the more rapid the variation of the field, the greater the current-density near the surface of the body, and the thinner the layer wherein the currents flow. The currents shield the interior from the varying magnetic field by superposing an opposing field of their own, while outside the body their field strengthens certain components of the original field. If the body is spherical, by harmonic analysis of the surface field we can separately evaluate the parts of external and internal origin; the method, due to Gauss, was first applied for this purpose by Schuster, to the *daily variation* of the earth's magnetic field. It is found that the daily-varying part of the field is mainly of external origin, but there is a smaller part of internal origin; Schuster ascribed this to currents induced in the earth by the outer varying field. In conjunction with Lamb, he showed that the ratio of the intensities of the external and internal parts of the field, together with the difference of phase between them, are inconsistent with the assumption that the earth is a uniformly conducting sphere. The magnetic data show, in fact, that the effective conducting sphere must be smaller. The depth of its surface is estimated to be about 200 miles, and its specific electrical resistance ρ is about 3×10^{12} e.m.u., or roughly 300 million times that of iron at ordinary temperature; naturally there is no reason to suppose that the resistivity undergoes a quite sudden transition at this depth. The resistivity 3×10^{12} is, however, 400 to 4000 times less than that of dry earth or rock, of which the outermost layer is formed, so that a great change of composition or state must occur at about 200 miles depth. There appears to be no other geophysical evidence of a rapid change in properties at this level inside the earth.

Even the outermost layer of the earth is sufficiently conducting for measurable currents to flow in it, but they are too weak to shield the conducting core from fields which vary with a period of the order of a day. During magnetic disturbances much quicker variations occur, and the measured earth currents, which are far stronger than usual, may have an appreciable shielding effect. The *oceans* are more highly conducting ($\rho = 2 \times 10^{10}$) than either rock or the conducting core, and if they covered the globe uniformly to a depth of half a mile the currents induced in them by the daily varying field would shield the interior almost completely, and the existence of the conducting core would not be disclosed; actually, the oceans are so broken up by land masses that the shielding effect of the currents induced in them is greatly reduced.

If the core is of *uniform* resistivity 3×10^{12}, the currents induced in it by the daily variation of the earth's field will decrease downwards until at a depth of about one-tenth its radius they are very small, and the outer varying field is almost annulled. The conductivity below this depth is therefore of no significance in relation to the daily magnetic variation, and we remain in ignorance of it. Our existing knowledge refers to a total depth of about 600 miles, or less if the conductivity of the core increases downwards; this outer layer shields the interior from outer varying magnetic fields of period one day or less. The conductivity of the deeper interior could be explored only by means of fields—which must be on a large scale, comparable with the earth's size—that vary much more slowly. There is an annual variation of the earth's field, probably of external origin, but it is small and not well determined: in time it may be used to ascertain the conductivity at lower levels, but at present this is not possible.

If the whole earth below 200 miles depth had the uniform resistance 3×10^{12}, freely decaying currents within it would be reduced in the ratio 10 to 1 in about five days: hence any currents producing the main field and the secular variation would have to be continuously maintained; moreover, the secular variation would be scarcely affected by self-induction, because its changes are periodic, if at all, only in a far longer interval, of hundreds of years. It may be, however, that the conductivity goes on increasing towards the earth's centre, the increasingly metallic character outweighing the opposing influence of rising temperature, and possibly also pressure, on the conductivity.

Fig. 6 shows in crude outline the estimated electrical resistance of different strata in the earth, and of the Heaviside layer in our atmosphere. It also shows the theoretical estimates I have made for different depths within the sun, which at the centre is probably nearly as good a conductor as copper is at ordinary temperatures.

Radial Limitation of the Sun's Magnetic Field.

Leaving terrestrial problems, let us again consider the sun's magnetic field. It has been seen that the tubes of magnetic force in the sun's atmo-

sphere lie nearly horizontal, and do not spread out into space as do those of the earth. Since the tubes are necessarily closed, they must complete their course inside the sun.

Hence the northward tubes observed in the sun's atmosphere must turn and become southward in the interior. Near the surface the force is northward and increasing downwards; since at some greater depth it is reversed in sign, it must first attain a maximum northward intensity and then decrease, become zero, and increase once more with the opposite sign. The depth and magnitude of the maximum northward intensity are unknown, and *a fortiori* the depth at which the force is reversed; if we knew these quantities, we could calculate the mean intensity of southward force below this depth, since as many tubes go northward as return southward.

By considering a line-integral of the magnetic force round a contour, in any meridian plane, formed of horizontal and radial lines, it appears by Ampère's rule that electrical currents must be flowing in the sun's atmosphere, along the circles of latitude, in the easterly direction as reckoned by an observer situated on the sun. The eastward electric currents extend approximately down to the depth of maximum northward force, below which the currents are westward—unless, which is perhaps unlikely, the field and the currents are reversed more than once inside the sun.

The *westward* currents are the primary cause of the sun's magnetic field, and their origin is the fundamental problem of solar magnetism. I have already described the theory, due to Larmor, which seems to give a possible explanation both of their origin and also of the earth's field. The second major problem of solar magnetism is afforded by the restriction of the field within the solar atmosphere. The immediate cause is the eastward current-system, which has the same effect as a shell of highly permeable magnetic matter enclosing the sun; it superposes an additional magnetic field which, in the external space, neutralises the primary field, while intensifying this field within the layer. The eastward currents cannot be the main cause of the sun's field: if they alone were present, their field would spread outwards into space.

It appears possible to account for these eastward currents in a simple manner by a theory which also enables the magnetic intensity to be used to calculate the pressure in the solar atmosphere, and gives a value agreeing well with that deduced in a totally different way by Milne.

The solar atmosphere is so hot that most of the atoms in it are ionised. The ions and electrons are subject to an electromagnetic force due to their motion in the magnetic field, and also to vertical gravitational and electrostatic forces. The electrostatic force is due to the tendency of the very light electrons to rise towards the top of the atmosphere. This tendency is almost entirely prevented, but a very slight separation occurs which suffices to equalise the downward forces on the ions and electrons; the ions are half supported by the electrostatic field, while the electrons are held down by it with a force equal to half the ionic mass.

Apart from these vertical forces, each of the ions and electrons would spiral round some line of magnetic force, the average motion therefore being to the north or south. Since the ions and electrons move equally to north and south, no average

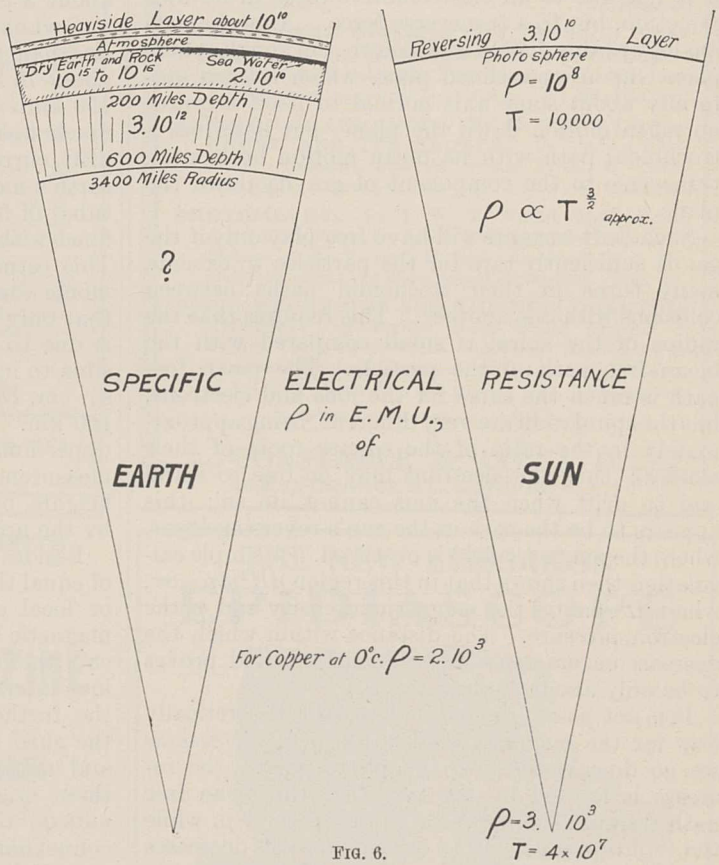

FIG. 6.

current results, and this motion along the magnetic field can for simplicity be ignored. The vertical force produces a constant downward acceleration of the free charged particle, but the magnetic field continually deflects the velocity round the lines of force, without affecting its magnitude. While a particle is moving downward its velocity is increasing, owing to the vertical force, but the magnetic field rotates the velocity, so that the motion becomes first horizontal and then upward again; during the upward motion the velocity is diminished by the vertical force, and turned so that the motion again becomes horizontal and then downward. The horizontal velocity at the top of the path is less than at the bottom, and the effect of the vertical force is to impart an average horizontal motion in the direction of the velocity at the lowest point of the path; there is no average vertical

velocity or acceleration. The motion, projected on the plane normal to the magnetic force (the vertical plane in the east-west direction), from being circular becomes trochoidal, the average velocity being to east or west. The motion is westerly for the electrons, which, viewed from the south, spiral round the field in the clockwise direction; for the positive ions, the motion of which is anti-clockwise, it is easterly. In either case the motion is equivalent to an easterly current, such as must exist in the sun's atmosphere, where the magnetic intensity is decreasing upwards; I have termed this current a 'drift' current, since it is not due to an electromotive force in its own direction, but to a transverse force. A mechanical analogy of this drift is well known. A rough sphere placed upon an inclined plane which rotates uniformly about some axis normal to itself acquires no mean motion down the plane, but describes a trochoidal path with its mean motion horizontal, transverse to the component of gravity down the plane.

Such drift currents will have free play only if the gas is sufficiently rare for the particles to execute many turns in their trochoidal paths between collisions with one another. This requires that the radius of the spiral is small compared with the mean free path of the particle. The mean free path is much the same for the ions and electrons, but the spiral radii are very different, being approximately in the ratio of the square roots of their masses; thus the electrons may be free to spiral and to drift when the ions cannot do so; this appears to be the case in the sun's reversing layer, where the magnetic field is observed. A simple calculation then shows that in this region $dH^2/dp = 8\pi$, where H denotes the magnetic intensity and p the electron pressure. The distance within which the decrease occurs can also be calculated, and proves to be only about 20 km.

It is not possible at present to infer theoretically how far the magnetic field is likely to *increase* as we go downwards into the photosphere; the increase is limited by the fact that the mean free path decreases downwards in the ratio $1/p$, while the 'spiral-radius' of the electronic paths decreases as $1/H$ or, approximately, as $1/p^{\frac{1}{2}}$. Hence the mean free path is reduced the more rapidly, and when it becomes approximately equal to the spiral-radius, the electronic drift current will cease. This must occur within 100 km. of the photosphere, but the calculation of the exact level is rendered difficult by the indefiniteness of the mean free path in the case of particles which are not rigid spheres, but behave like point centres of force, particularly when the law of force is the inverse square law of electrostatic action.

In these calculations no account has been taken of the influence of the magnetic field on the mechanical equilibrium of the sun's atmosphere. The field partly supports the free charges, and an atmospheric layer of given total mass will therefore be more spread out, in the vertical direction, than if the field were absent. When this effect is allowed for, the formula $dH^2/dp = 8\pi$ is modified, but the drift-current theory of the radial limitation of the field is not essentially changed.

Terrestrial Drift Currents and other Electromagnetic Phenomena.

Similar effects must occur in the earth's atmosphere, which is ionised at high levels by solar radiations. Eastward drift currents will flow at heights where the mean free path is larger than, or comparable with, the spiral-radius of ions and electrons; in the earth's field, at the equator, the spiral-radius is about 2 cm. for an electron, and 5 metres for an ionised oxygen or nitrogen molecule; consequently *electronic* drift currents will occur at heights above about 70 km., and *ionic* drift currents above about 150 km. But the number of electrons and ions is much less than would be required to enable the drift currents to shield the outer space from the earth's magnetic field; less than 5 per cent of the tubes of force crossing the earth's surface are confined within the atmosphere by the drift currents. This estimate is derived from the spherical harmonic analysis of the earth's field, which shows that only about 3 per cent of the surface intensity is due to overhead currents; from this it is possible to infer that there are less than 10^{16} ions per sq. cm. column of atmosphere, above a height of 150 km. An independent check on this estimated upper limit will become available before long from measurements of the ionic density at different heights, by means of the reflection of wireless waves by the upper atmosphere.

Besides these major problems, there are others of equal theoretical interest, which relate to smaller or local components of the solar and terrestrial magnetic fields. The solar corona appears to indicate the existence of a magnetic field, probably of low intensity, above the chromosphere. Among the further phenomena of terrestrial magnetism, the chief are the solar and lunar daily variations, and magnetic storms with their associated auroræ; these originate above the earth's surface, in or outside our atmosphere. They have important connexions with solar physics, and also with so practical a matter as radio propagation; in recent years the electrical exploration of the upper atmosphere by beams of radio waves has lent powerful aid in their investigation. During the past century some progress has been made towards a physical theory of these changes, but much more remains to be done.

The problems involved, like those relating to the main field of the earth, are of rather long standing; they probably depend only on the working of already known laws, in ways not yet recognised, and therefore they do not possess the importance that attaches to such problems as those of atomic physics; nevertheless, they have much fascination and interest, and until they are solved they constitute a challenge to the theoretical physicist; in time the challenge will be met, but that time may be still distant.

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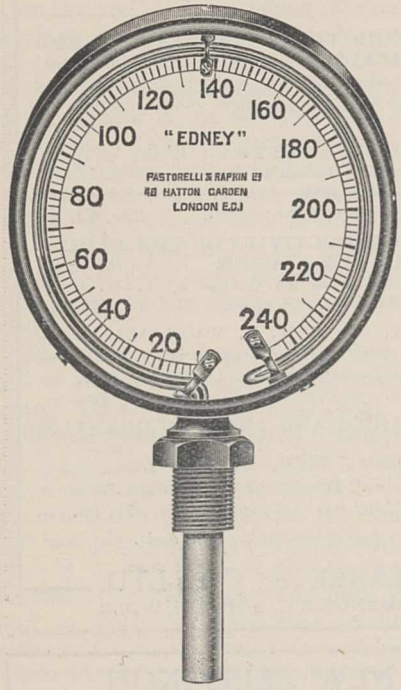

Fig. 1. VERTICAL PATTERN
Front view.

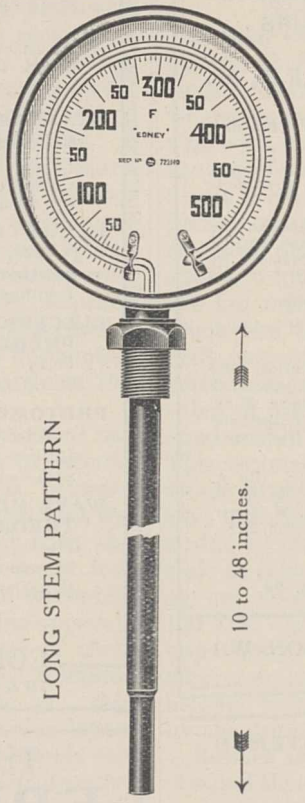

Fig. 3.

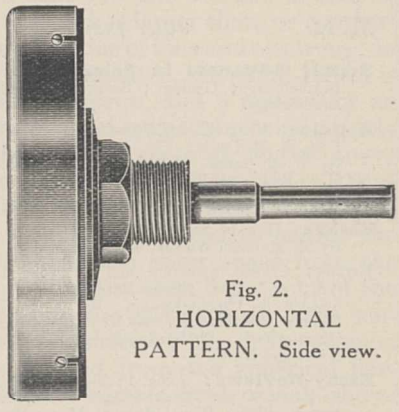

Fig. 2.
HORIZONTAL
PATTERN. Side view.

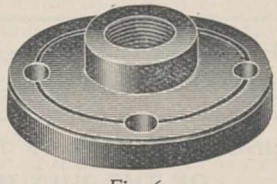

Fig. 6.
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„ 5. „ 3.	Ranges up to 600° or 800°, 4-inch dial 18" „ **36s.** 24" „ **40s.** 36" „ **44s.** 48" „ **48s.**		
	„ „ „ 6-inch dial 18" „ **42s.** 24" „ **46s.** 36" „ **50s.** 48" „ **54s.**		
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exhibits auxiliary to local industry come from the south. The Cambridge Scientific Instrument Company supplies its pyrometers to brick and tile works.

The natural advantages already described are open to those who wish to start new industries. In chemicals, iron, engineering, and shipbuilding it may be less easy to begin on a small scale than it was a century ago with less powerful competitors. But the district seems a good one for new inventions operating new patents. Coal, gas, and electric current are available as power. There is a network of railways and motor-bus routes. There is superabundant labour already somewhat housed. New ventures will be welcomed by a population reluctant to emigrate although ill-advised in leaving initiative to others. The large-scale models of the Tyne Improvement and Tees Conservancy Commissioners will help in the choice of sites for factories; the L.N.E.R. is also ready to advise. Industries scarcely yet acclimatised include the making of agricultural machinery and motor-lorries.

This exhibition goes much further than earlier attempts to restore confidence by talking confidence. The goods are ready. The method of advertisement is being pushed for all it is worth. Word has gone out through the world in English, French, German, and Spanish. There will be conferences of advertisers, of international foundrymen, and notably the Baltic and White Sea Conference. The success of the exhibition is to be judged by orders for ships, bridges, and machinery rather than by gate-money on bank holidays. The method of advertisement may have its limits; it may lead to private profit at the price of public waste. The exhibition and its catalogues are examples of economy in advertisement by co-operation, a stepping-stone towards the transformation of advertisement into a public service. The relation of the co-operative wholesale society to the co-operative stores in the pit-villages tends towards the tied-house principle, eliminating the need for advertisement. Even if the method of advertisement cannot command success, it is doing what it can to deserve it.

So much for the microcosm in which the scientific explorer will find himself if he comes to make the exhibition a starting-point for some survey of the north-east of England. The causes of present distress have been incompletely advertised. It is not only a post-War slump in munitions. For fifty years Tyneside has been content to make high profits and high wages whilst specialising in the production of munitions. Nemesis has come home with a vengeance. There is a heavy load of the disabled to be carried; the education of the blind is the only formal educational exhibit. The unemployed include the less employable and the less versatile. Leadership has been decimated. Unemployment as a name for a scarcity of employers is a view not emphasised by labour leaders. Labour propaganda has looked numbly to the State. During the coal stoppage of 1926 it may have seemed right to say hold on and hope. In retrospect, emigration would have been wiser. Many of the inland coal mines, for example near Bishop Auckland, are worked out, though the deeper mines near the Durham coast are at work. It seems a tragic mistake that emigration has been discouraged by those to whom the miners look for advice. The Lord Mayor's Fund has been a gesture of generosity; it only makes idleness a trifle less intolerable.

Various tempers of mind—religious, philanthropic, political—have already been applied to our problems without yielding complete solutions. Before prescribing panaceas we need the whole truth. It is whispered that in the past it has been far too easy to make money on Tyneside. This view is endorsed by Dr. H. A. Mess in "Industrial Tyneside". Traditional industries have scarcely thought it necessary to bring in scientific advice; even to-day a chemist is felt to be out of place on a board of directors. Some industries requiring high intelligence have left the district; electric lamps and aniline dyes are examples. So far there is too little response to the offers of the National Institute of Industrial Psychology to help in selecting personnel and arranging work. There is a reluctance to climb down from high prices, high profits, and high wages.

What is to be done if the method of advertisement fails? The restoration of the general prosperity of our neighbours beyond the North Sea is urgent. A voluntary Interessengemeinschaft between chemical firms, already in the imperial stage of evolution, would be a safeguard against future misuse of nitrates and by-products. Armstrong College, fed by scholarships through the secondary schools, is preparing the next generation of employers. Even if the rest of England hesitates there seems a fair case for asking for a prior and immediate application of the Hadow Report raising the school age by one year in the colliery areas. For the next or prevocational year up to age sixteen the teachers are still to be discovered and trained. A great development of junior technical schools is desirable until every young person has at least one and preferably several ways of earning a living. It is proving very difficult to reconvert townsfolk into agriculturalists. There is a Migration Training Hostel for boys in Walker, and a Domestic Training Hostel for girls in Benton, but what are these among so many?

Emigration is probably urgent and almost without waiting to ask whether the new countries will speak Russian, Spanish, or Dutch. When customers are invited from all nations it seems absurd to limit emigration to the British Empire. The nations emigrating to America have faced a new language and an alien culture. A generation ago the Irish had to leave home: a like fate is before our boys and girls. The best ages for emigrating are said to be sixteen to twenty-three, and the best form of assistance education and training whilst still near home. Some sort of vocational guidance might be offered to every one, followed by technical training according to capacity. The boys and girls in their school caps and badges are seen eagerly examining the exhibits; to them the exhibition is a means of education.

HUGH RICHARDSON.

South Africa Meeting of the British Association.

THE meeting opens on Monday, July 22, and for the convenience of members who arrive in Cape Town before this date, offices and reception rooms are being opened in the old University Buildings, Queen Victoria Street, on July 15. Business in connexion with railway travel and with local excursions will be transacted at these offices. The meetings of the sections will be held in the new University buildings at Groote Schuur, Rondebosch, which can be reached by rail, tram, or bus from Cape Town.

Local excursions to points of interest and beauty in the Cape Peninsula are being arranged, and the Royal Observatory will be open for inspection. It is hoped that the cable railway to the top of Table Mountain will be ready for traffic, thus facilitating the ascent. For visitors interested in geology, excursions are being arranged for an inspection of the granite-slate contact at Sea Point and to Chapman's Peak, where a general idea of the structure of the Cape Peninsula can be obtained. On the way from Cape Town to Kimberley, geologists will have an opportunity of inspecting the Folded Mountain Belt, the Cape System, and the Karroo System ; at Kimberley they will be able to inspect the diamond mines and the glacial phenomena of the Dwyka Series. Thereafter, on arrival at Johannesburg and Pretoria, they may link up with the International Geological Congress.

It is anticipated that about 550 visitors from overseas will attend the meeting, and the transportation of these, together with a number of local members, by rail from Cape Town to Johannesburg in a limited time will tax the resources of the railway, which runs for most of the way as a single track and has many steep gradients. A special train for local members will leave Cape Town on Saturday, July 27 ; two special trains for visiting members will leave Cape Town on the morning of Sunday, July 28, and two more on the morning of Monday, July 29. Each of the parties of visiting members will spend about twelve hours at Kimberley, and will then proceed to Johannesburg, where they will arrive on July 30 and July 31.

At Kimberley the diamond mines of the De Beers Consolidated Mines will be visited. It is anticipated that practically all of the visitors will desire to see the workings of a gold mine. The underground workings of the mines can only be visited during the early part of the day, as all underground passages must be cleared for blasting operations during the afternoon. The visitors will be taken in small parties to various mines ; for those specially interested a small party is being organised to visit one of the deep, hot mines.

Astronomers will be afforded an opportunity to visit the Union Observatory and the Yale telescope, which is housed in the grounds of the University of the Witwatersrand.

The meetings of the sections in Johannesburg will be held in the University of the Witwatersrand, and the premises of the Associated Scientific and Technical Societies of South Africa, in the centre of the town, will be available for the visiting members.

Visits have been arranged to the Rand Gold Refinery, to the explosives factory of African Explosives and Industries, Ltd., at Modderfontein, and to the Royal Mint at Pretoria. The large air-compressors of the Victoria Falls Power Company at Rosherville will be of interest to engineers, as will also be the Central Electric Power Station at Witbank. The Rand Water Board has arranged a visit to the barrage across the Vaal River and to the waterworks at Vereeniging. For anthropologists visits can be arranged to the Leslie collection of stone implements at Vereeniging, to stone circles at Aasvogel Kop and at Heidelberg, to the native stads at Rustenburg, and to stone huts at Vechtkop (Heilbron, O.F.S.). Several botanical excursions are being organised, as also are visits to institutions of an educational character. The South African Institute for Medical Research at Johannesburg and the Government Veterinary Research Laboratories at Onderstepoort, near Pretoria, will be open for inspection. On the morning of Sunday, Aug. 4, exhibitions of native war dances will be given. A display of tribal types is being organised by the Witwatersrand Native Labour Association, which should prove to be a particular attraction to all overseas visitors. From Pretoria a visit will be made to the Premier Diamond Mine.

Under the auspices of the South African Association, a handbook dealing with South Africa from the travel and scientific aspect has been prepared for presentation to visiting overseas members. The book contains a foreword by His Excellency the Earl of Athlone, Governor-General, and chapters on travel in South Africa, Southern Rhodesia, government, education, geology, gold, diamonds, other minerals, agriculture, vegetation, fauna, astronomy, anthropology, medical research, commerce, and game reserves. The book will be available to members at Cape Town, and the information in it should add to the interest of the visit to South Africa. Portfolios of etchings will be presented to overseas members at Cape Town ; the etchings depict typical South African scenery and architecture (chiefly in the neighbourhood of Cape Town), and will form a not uninteresting souvenir.

At the opening session on Monday, July 22, at Cape Town, members of the British Association will be welcomed to South Africa by His Excellency the Governor-General. At this session the South Africa Research Medal (founded in commemoration of the visit of the British Association to South Africa in 1905) will be presented to Dr. Robert Broom for his archæological and anthropological researches.

The South African Association has extended invitations to a number of scientific workers to attend the meeting in South Africa as guests, and Prof. O. Abel, Sir J. C. Bose, M. l'Abbé Breuil, Prof. C. Dragoni, Prof. A. S. Eddington, Prof. A. S. Hitchcock, Prof. G. A. F. Molengraaf, Dr. C. S.

Myers, Sir John Russell, and Dr. W. de Sitter are expected to be present.

One evening at Cape Town will be devoted to a discussion on science and industry, which will be continued on another evening at Johannesburg.

The meeting concludes officially at Johannesburg on Aug. 3; thereafter most of the visitors will proceed on sight-seeing tours, and doubtless many of them will take the opportunity of visiting the Victoria Falls. One party will assemble at Durban towards the end of August, and a semi-official session will be held there; this party will be joined by the president, Sir Thomas Holland, who will give a special address at Durban.

News and Views.

AN important step in the development of the Waite Institute for Agricultural Research, South Australia, was taken when the John Melrose Laboratory was officially opened at the end of April. The Institute was established some years ago as the result of a gift by the late Mr. Peter Waite to the University of Adelaide for the purpose of furthering education and research in agriculture and allied subjects. The endowment comprises the Urrbrae, Claremont, and Netherby Estates lying on the scarp of the Adelaide foothills within four miles of the city and consisting of nearly 300 acres. In addition there is a trust fund of £58,450. Of recent years considerable assistance has been forthcoming from the State Government, Empire Marketing Board, the Council for Scientific and Industrial Research, Imperial Chemical Industries, Ltd., and the Commonwealth Bank of Australia. The need for increased laboratory accommodation has been acutely felt, and, mainly through the generosity of Sir John Melrose in providing the sum of £10,000, a wing has been completed of what will in time constitute a large block of laboratory buildings.

THE Melrose Laboratory at the Waite Institute contains two main floors, the ground floor being devoted to administrative and botanical work, and the first floor mainly to chemical work, but with provision also for entomology. The entire content of the building is approximately 274,000 cubic feet and the total floor space 14,700 square feet. Quite possibly further extensions may soon prove necessary, as it is understood that the Council for Scientific and Industrial Research and the University of Adelaide are discussing a project for establishing jointly at the Institute a Division of Soils Research. The need for a move of the kind has been very apparent in Australia for some time, and there can be little doubt that its establishment at the Waite Institute would be a wise move, as this Institute is rapidly becoming one of the most important centres of agricultural research in the Commonwealth.

MESSRS. SOTHERAN, LTD., booksellers, Strand and Piccadilly, have in their hands and are proposing to sell *en bloc* a collection of some eight hundred and sixty books which undoubtedly formed a part of a library brought together by Sir Isaac Newton. It had been known to a past generation that at Newton's death a large mass of papers, annotated copies of his own and other authors' works, and an extensive correspondence with English and foreign mathematicians, remained with Mr. Conduitt and his wife. Ultimately those of this series which related to science were presented to the University of Cambridge in 1872 by the Earl of Portsmouth, and were reported on in 1888 over the signatures of such authorities as H. R. Luard, G. G. Stokes, J. C. Adams, and G. D. Liveing.

THE works that actually constituted Newton's library occupy, however, a different niche in history, unrecorded as an entity by his biographers. One may, perhaps, conjecture that the volumes were left intact at the house in St. Martin's Street, Leicester Fields (occupied for so long by the philosopher), and not removed on his change of quarters, through ill-health, to Kensington, where he died within a brief space, in 1727; certainly the old residence was still on the rate books of his former parish at that date. Twenty books in the above collection bear Newton's autograph; four are dated 1661; whilst eighty-three carry, here and there, notes in his handwriting. The first and second editions of the "Principia" (with numerous corrections) are prime items of interest in the set. Some of the books have presentation inscriptions to Newton by their authors; others are finely bound in contemporary morocco. A Latin-Greek Dictionary (1650) with autograph, has the date Mar. 29, 1661, presumed to be the earliest known Newtonian signature, in any case, written shortly before he entered Trinity College, Cambridge.

FROM a reprint of the correspondence between Isaac Newton and Robert Hooke during the years 1679–1680, published in chapter viii. of Rouse Ball's "Essay on Newton's Principia", pp. 138-153 (Macmillan), 1893, two letters were missing. These letters "are known to have been written, but they have never been published, and it is possible that no copies of them are now extant". The correspondence dealt with the question of the path of a falling body, "moved circularly by the diurnal motion of the earth, and perpendicularly by the power of gravity". The first of the missing letters was read to the Royal Society on Dec. 11, 1679, two days after Hooke sent it to Newton. The reply from Newton, dated Trin. Coll., Dec. 13, 1679, and addressed: "For Mr. Robert Hooke, at his Lodgings in Gresham College in London," was discovered in a collection of autographs, sold in 1904 by Messrs. Sotheby to the British Museum. Thanks to the courtesy of the Keeper of the Manuscripts, Dr. Jean Pelseneer of Brussels has been permitted to print (*Isis*, xii. No. 38, May 1929) the hitherto unpublished letter. The 'find' is not only interesting in itself for the part that it played in the history of the genesis of the "Principia", but also as an earnest of more to come. Thanks to the assistance he has received from the Belgian National Fund for Scientific Research, Dr. Pelseneer hopes to bring before the public further

documents by Newton which have not yet been published. We may add that in the *Isis* article of 16 pp. he gives his readers an excellent summary of the correspondence, with the circumstances in which it was written.

THE Meteorological Office, Air Ministry, has issued a special report upon the shortage of rain over the British Isles during the period of six months including December last and the first five months of the present year. Except to certain sections of the community who for special reasons are intimately concerned with the total amount of rain during such a long period, as for example farmers and engineers who deal with water-supply, a shortage of the kind under consideration may easily pass unnoticed. This is particularly the case when the dry spell has been marked by not infrequent periods of dull, windy and wet weather during which appearances have been misleading and the amount measured in a rain-gauge has been trifling. The official report is accompanied by a map showing the rainfall for the six months expressed as a percentage of the normal fall for the same period. This map reveals the fact that only the coastal districts of the south of Ireland and the extreme south-west of England show any considerable areas where there has not been a deficiency, and that over a considerable part of north-west Ireland, western Scotland, Wales and England, there has been less than half the usual quantity.

AMONG places mentioned in the report which show particularly low percentage amounts of rainfall are Llangurig (Montgomery), with 30 per cent; Rhyader (Radnor), with 35 per cent; Margate, 36 per cent; Fort Augustus (Inverness), 38 per cent, and Aspatria (Cumberland), 39 per cent. At Margate the remarkably low total fall of slightly less than 2¾ inches was measured. It is interesting to note that the last month of the series—May—was the only one in which the British Isles as a whole showed a slight excess rainfall above the normal, and there seemed to be some hope that the tendency for drought had come to an end. June has, however, showed some notable dry periods, and when the figures for that month are collected and the period of seven months from last December is considered, the general shortage will probably stand out as one of the most notable, if not the most notable, of any dry period of that length in Great Britain since accurate rainfall measurement began.

THE approaching visit to South Africa of the British Association has undoubtedly stimulated interest in its many archæological and ethnological problems, not least perhaps those which centre in the prehistoric stone buildings, of which the greatest and best known is Great Zimbabwe. In addition to the expedition, of which Miss Caton-Thompson is the leader, sent out by the British Association itself, and the independent investigations being carried out under permit of the Rhodesian authorities by Dr. Leo Frobenius, an Italian expedition is in the field. It has been sent out under the auspices of the Royal University of Florence. One of the members, Dr. Lidio Cipriani, professor of ethnology in the University of Florence, is reported in the *Times* of June 21 to have arrived at the conclusion that the Zimbabwe collectively are a native product, the work of an African people without any foreign influence. It is to be hoped that Dr. Cipriani may have an opportunity of laying his views before the Association. Dr. Cipriani is also reported to have discovered some Bushmen paintings of exceptional significance. They exhibit the feature of superposition, a painting of an Arab typically dressed having been found under a picture of a Bushman fighting Bantus. This, needless to say, confirms the relatively late date of the Bushman paintings, some of which indeed are known to be quite modern. These paintings were found in the Marandellas district. An engraving found at Mazabuka is said to be like nothing found elsewhere in Africa and to give certain indication of prehistoric man. The description, however, is too vague to give any clear idea of its character.

As was announced in our issue of June 22, p. 951, by arrangement with the Air Ministry and Messrs. Wireless Pictures (1928) Ltd., synoptic weather charts are being broadcast from the Daventry Station (5 XX) of the British Broadcasting Corporation every Tuesday and Thursday between 2 P.M. and 2.25 P.M. Reports of the reception of these charts on a Fultograph from as many different places as possible will be of the greatest value to the experimenters. Any possessor of a Fultograph can obtain a supply of prepared paper and envelopes and also full particulars of the reports required by writing to Wireless Pictures (1928) Ltd., Dorland House, 14-16 Regent Street, London. We hope that the results will demonstrate that it is possible to send in a few minutes from a central station to all parts of the country, and to airships and aeroplanes in flight, weather charts and forecasts. It will be of the greatest value for pilots to see at a glance the state of the weather in the districts to which they are flying.

THE history of Danish broadcasting is a notable example of the wisdom of State encouragement of amateur effort. In the *Wireless World* for June 19 a good account is given by P. O. Langballe of the rise of broadcasting in Denmark. In 1922 it came into existence almost accidentally. Government tests were being made with the view of establishing radio telephony between the mainland and the Island of Bornholm, using a Poulsen continuous wave transmitter. During these tests several amateurs were surprised to hear something that sounded like the scratching music made by an old gramophone. When regular reception was established, it was found impossible to prevent 'listening in'. Private transmission, however, was forbidden. This led to the formation of the Danish radio club, the members of which were anxious to secure the same privileges as radio enthusiasts in other countries. A modern valve transmitter was erected at a station just outside Copenhagen. Although the plant was supplied by the State, its operation and maintenance were entrusted to the radio club. This arrangement proving

a success, no difficulty was experienced in getting permisson to erect a broadcasting station in Copenhagen itself, funds being provided by the State and a few private subscribers. The club operated this new station at first, but as the programmes became elaborate and the expenses heavy, the State assumed control and a radio bill was passed taxing all listeners. The tax is now a uniform one of ten crowns per annum. The first relay stations were fitted on the passenger steamers between Copenhagen and Jutland. They picked up the Copenhagen programmes and transmitted them. A high power station has now been built at Kalundborg on the western coast of Seeland. The ratio of licensed listeners to the total population is greater in Denmark than in any other country in the world.

AN expedition under the auspices of the German Government to study the ice-sheet of Greenland is being undertaken this year. Prof. A. Wegener, who has had previous experience in Greenland, will be in charge. This year's work will be by way of preparation for the main undertaking next year. According to the *Geographical Journal* for June, three stations will be established in the same latitude but at wide intervals. The first will be about 12 miles within the ice-sheet in the Umanak district. The second will be in the central part of the ice-sheet, and the third will be on Scoresby Sound. Wintering parties will inhabit all the stations and take the temperature of the ice at different levels. Radio and weather forecasting stations will be established at the three stations. It is proposed to use motor sledges as well as dogs and Icelandic ponies in transport.

IN his address to the Royal Geographical Society at the annual general meeting on June 24, Sir Charles Close referred to the growing value and importance of air surveys. Some attempts at aerial photography were made last century, but nothing practical in aerial survey was achieved until the aeroplane supplanted the balloon as a means of air transport. It was during the War that air photography became a recognised method of survey. Sir Charles Close went on to give some account of air surveys that have been made or are in process of completion. Perhaps the outstanding example of aerial survey is that of the difficult country in Brazilian Guayana along the Rio Negro, Rio Branco, and Rio Parima. The whole is covered with dense forest, but about 12,000 square miles were photographed in 174 hours. Then the detail was fitted into a framework of astronomically fixed positions which were made along the rivers. As a quick means of survey in new countries, aerial photography has been used in Northern Rhodesia, Iraq, Burma, and the Rio de Janeiro district in South America, the Malay States and elsewhere. Rapid improvements in the cartography of many of the less known parts of the world are thus rendered possible.

A LARGE earthquake was recorded at Kew Observatory on June 27. The first tremors reached the Observatory at 13 hr. 1 m. 38 sec. G.M.T. The epicentre is estimated to have been 7500 miles away, but the initial impulse was too small to be any indication of the bearing.

MR. L. BELLINGHAM, of Messrs. Bellingham and Stanley Ltd., 71 Hornsey Rise, N.19, reminds us that the electrification of omnibuses described by Prof. C. V. Boys in our issue of June 29 was pointed out by him in NATURE of Sept. 10, 1927, p. 367. He believes the charge is the result of the friction on the brake drums rather than the rolling of the tyres on the asphalt, because he has noticed it particularly on the buses descending Crouch Hill on the portion of the road which is paved with granite setts. These small electric shocks are well known to the conductors, but they attribute it to a slight leakage from the magneto.

IT is probably known to our astronomical readers that for the measurement of positions and areas of sunspots a collection of solar photographs for each day of the year is made at Greenwich with the co-operation of the observatories of the Cape and Kodaikanal. In most cases there are two or more photographs for each day. One complete set is preserved at the Royal Observatory, and we are informed that arrangements have recently been made for a duplicate set to be stored at the Science Museum, South Kensington. This has the great advantage of housing two complete sets at different places, in case of accident; also the set at the Science Museum is easily accessible to students of astronomy and magnetism who may wish to consult the negatives.

AT the meeting of the Geological Society held on June 26, the following foreign members were elected: Prof. Charles Schuchert, of Yale University, New Haven, Connecticut; Prof. Pierre Termier, Directeur des Services de la Carte Géologique de France, Paris; Dr. Edward Oscar Ulrich, U.S. Geological Survey, Washington, D.C.; and Dr. Thomas Wayland Vaughan, Director of the Scripps Institution of Oceanography, University of California. Foreign Correspondents were also elected as follow: Prof. Othenio Abel, of Vienna; Dr. Clarence N. Fenner, of Washington, D.C.; Prof. Olaf Holtedahl, of Oslo, Norway; Dr. Rudolf Staub, of Berne, Switzerland; Dr. V. K. Ting, of Peking, China; and Prof. Carl Wiman, of Upsala, Sweden.

IN the Calendar of Patent Records which appeared in the issue of NATURE for June 1, the entry relating to the invention of vaseline referred to the provision of the law which denies registration as a trade-mark to a commonly-used descriptive word, and cited 'vaseline' as a case to which this provision had been applied by the British Courts. Mr. R. F. Kennedy, 12 Church Street, Liverpool, has pointed out, however, that although the lower Court ordered the removal of the mark 'vaseline' from the register on the grounds stated, this decision was afterwards reversed by the Court of Appeal, and the registration of the word as a trade-mark, first effected in 1877, remained in force.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—A scientific officer and a junior scientific officer on

the Air Ministry Scientific Research Staff, primarily for duty at the Royal Aircraft Establishment, South Farnborough—The Chief Superintendent, Royal Aircraft Establishment, South Farnborough, Hants (July 6). An engineer for the Fruit Storage Research Station, East Malling—The Secretary, Department of Scientific and Industrial Research, 16 Old Queen Street, S.W.1 (July 6). A lecturer in pharmaceutics at the Chelsea School of Pharmacy—The Principal, Chelsea Polytechnic, Manresa Road, S.W.3 (July 6). A whole-time assistant (male) to the Public Analyst—The Secretary, Health Department, Grey Friars, Leicester (July 6). An assistant lecturer in mechanical engineering—The Principal, Municipal College of Technology, Manchester (July 8). An assistant lecturer in mechanical engineering at the Bath Municipal Technical College—The Director of Education, Sawclose, Bath (July 8). A resident engineer in connexion with the Sea Wall and Embankment Scheme—The Town Clerk, Municipal Offices, Liverpool (July 9). An assistant lecturer in electrical engineering at the Technical College, Bradford—The Director of Education, Town Hall, Bradford (July 10). A headmaster for the Sandown County Secondary School—The Director of Education, County Hall, Newport, I. of W. (July 11). A full-time assistant to take charge of the electrical engineering National Certificate courses—The Principal, Technical College, Wolverton, Bucks (July 12). A resident lecturer in mathematics with subsidiary science—The Principal, Saltley Training College, Birmingham (July 12). An assistant water engineer—The Town Clerk, Town Hall, Bexhill (July 12). An honours graduate as demonstrator in zoology—The Secretary, Queen's University, Belfast (July 13). A lecturer and demonstrator in pharmacy—The Principal, Central Technical College, Suffolk Street, Birmingham (July 13). An engineering assistant in the Highways and Bridges Department of the Surrey County Council—The Clerk to the Council, County Hall, Kingston-on-Thames (July 13). A professor of municipal engineering and town planning and a professor of railway and road engineering at the Royal School of Engineering, Giza, Cairo—The Director, Egyptian Education Office, 39 Victoria Street, S.W.1 (July 15). A full-time teacher for the Marine Engineering Department at the L.C.C. School of Engineering and Navigation, High Street, Poplar, E.14—Education Officer (T.1a), The County Hall, Westminster Bridge, S.E.1 (July 15). A part-time instructor in mechanical engineering—The Principal, Technical School, Watford. A principal of the Kenrick Technical College—The Director of Education, Education Offices, Highfields, West Bromwich. A test assistant to assist in chemical analysis of metals and alloys—The Chief Superintendent (quoting A.355), Royal Aircraft Establishment, South Farnborough, Hants. An assistant mechanical engineer for the Railway Department of the Government of Ceylon—The Crown Agents for the Colonies (quoting M/1581), 4 Millbank, S.W.1. A mechanical engineer in the Ministry of Public Works, Cairo—The Chief Inspecting Engineer, Egyptian Government, 41 Tothill Street, S.W.1. An assistant experimental officer for design duties for Government Establishment at Biggin Hill, Kent—The Secretary, R. E. Board, 14 Grosvenor Gardens, S.W.1.

Our Astronomical Column.

Origin of the Planetary System.—The May issue of *Mon. Not. R.A.S.* contains a paper on this subject by Dr. H. Jeffreys. He gives a résumé of various theories, starting with that of Buffon, who suggested that a massive comet struck the sun. Many subsequent theories supposed that the near approach of another star to the sun caused the outrush of a stream of matter from it by tidal action. The rotations of the sun and planets were explained as due to the return of a portion of the expelled matter to them after it had received a transverse deflection, from the attraction of the star in the case of the solar matter, or of the sun in the case of that returning to the planets. He examines this suggestion numerically, and finds that it does not give rotations of the right order for the large planets. He then examines the suggestion that the other star actually collided with the sun, and that as they separated a long filament of matter was drawn out between them; this, like the tidal filament in the theory of approach without collision, is supposed to have broken up into the planets. It would also receive a rotational motion by the pull of the other star. On certain assumptions, Jeffreys finds that the mass of the filament might be 1/500 of the sun's, and that the periods of rotation of the resulting planets would be of the order of 8 hours, in good agreement with the actual values for the large planets.

Objections had been made to the tidal theory on the ground that close approaches of stars would be extremely rare; obviously actual collisions would be rarer still, so the adoption of the theory would seem to imply that planetary systems are excessively rare in the universe.

Periodic Comets.—*L'Astronomie* for May contains an article by M. F. Baldet in which he gives a useful table of elements of all the comets known to have periods less than 170 years. It is quite up-to-date and includes the two most recent discoveries, Pons-Forbes and Schwassmann-Wachmann II. There are two lists, the first consisting of thirty-one comets observed at more than one apparition. Three of these are marked with an asterisk, indicating that the identity of the objects seen at the two returns is not absolutely certain; twenty-two of them belong to Jupiter's family, one to Saturn's, two to Uranus's, five to Neptune's, and one has a period of 164 years (seen in 1742 and 1907). The second list contains those seen at only one apparition; it contains thirty-five comets, twenty-two of which belong to Jupiter's family; of the others, five have periods between 11 years and 18 years, two between 40 years and 46 years, three between 64 years and 80 years, and three exceeding a century. Two comets of the second list are due at perihelion in the present year. Mr. F. R. Cripps has computed the perturbations by Jupiter of Giacobini's comet 1896V from its discovery to the present time; he finds perihelion occurs next September and gives a search ephemeris in the *B.A.A. Journal*, No. 7. The *B.A.A. Handbook* gives ephemerides for Perrine's and Metcalf's comets, both of which are due at perihelion this year.

Research Items.

Boyle as a Philosopher of Science.—In the recent issue of *Archeion* (vol. 11, No. 1, pp. 1-12), G. W. Spriggs estimates Boyle in his capacity of a critical and constructive philosopher. The author justly observes that Boyle has become a figure of uncertain importance in science; his claim to recognition is usually based upon the law associated with his name, and upon rather vague statements to the effect that he is the father of modern chemistry. The bulk of his writings, and the dryness of his style, have doubtless combined to prevent his ideas from receiving adequate attention by modern historians of science. Mr. Spriggs shows that Boyle introduced much improvement in scientific reasoning, acutely criticised the old and vexed question of the 'qualities' of bodies, and, by his conceptions of *minima* (small undivided particles) and 'local motion', paved the way for fundamental advances in scientific thought. As an experimental investigator he was seldom surpassed for patience, resource, and accuracy, while in many of his penetrating analyses of his observations are to be found the germs of ideas current even to-day. He did much to clear away the scholastic undergrowth which hindered scientific progress, and formulated conditions under which scientific work should be carried out in order to discover the truths of Nature. It is clear from Mr. Spriggs' all too brief essay that a full study of Boyle's writings would be a very welcome contribution to the history of science.

Rock Carvings in the Italian Alps.—In *Antiquity* for June, Mr. Miles C. Burkitt discusses the origin and purpose of the rock carvings on the slopes around Monte Bego in the Italian Maritime Alps. The only systematic study of these carvings in the neighbourhood of Bordighera was that made by Mr. Clarence Bicknell, who, beginning in the year 1897, in the following twenty years made rubbings of some 15,000 carvings. The carvings fall into three classes: (1) Animals; (2) weapons and tools; (3) signs, patterns, and scenes. The animals are predominantly oxen. There are several human figures, mostly associated with ploughing scenes. The drawings are nearly all conventionalised, and the figures represented as though seen from above. The weapon most commonly figured is the triangular dagger with a handle. The halberd is also shown. As the carvings are at the head of valleys leading up to Monte Bego, and this mountain is an important cyclonic centre, of which the peasantry fully recognise the importance in connexion with the weather, it is suggested that the carvings may be the expression of a seasonal agricultural cult which took the form of an annual pilgrimage such as those which have been perpetuated in Italy under the Church. The object of the pilgrimage would be to secure weather propitious for the crops and animals from the spirit of the mountain. As regards their age, there is no evidence of habitation before the period of the carvings, and though culturally all the carvings can be assigned to the Early Bronze Age, it does not necessarily follow that they can be associated in time with the industry of the lake dwellers. On the other hand, the Iron Age peoples do not appear to have penetrated these mountains, but the absence of any Christian symbol shows that they must have been produced prior to A.D. 300.

Association of the Tuatara Lizard with Nesting Petrels.—A note on some features of this curious association between a lizard and a bird appears in the special scientific number of the *Municipal Record* of the Auckland City Corporation, issued on the occasion of the visit of the New Zealand Institute Science Congress in January last. Tuataras still live in fair numbers on eight or ten groups of islands near East Cape, and these are inhabited also by different species of petrels. In many cases the burrows of the petrels are shared by tuatara and petrel during the nesting season, while in the winter, when old and young petrels have departed for the northern hemisphere, the tuatara digs itself in at the end of the burrow to hibernate. The association as a rule is one of *laissez faire*; both petrel and tuatara, the note relates, sleep during the day, and at night, when the lizard issues to hunt nocturnal insects, the petrel also goes about its business. Occasionally the lizard may devour the solitary chick of the petrel, but often it just leaves it alone. It appears that in the first instance the burrows are made by the petrel, but the lizards are long-lived, and, surviving the birds, eventually may remain sole occupants of the tunnel.

Effect of Low Temperature on Mitosis.—F. G. Spear (*Arch. f. exp. Zellforsch.*, 7; 1928) records observations on the effect of low temperature on mitosis in tissue obtained from the choroid and sclerotic of chick embryos of 7-8 days' incubation grown in fowl plasma and chick embryo extract on coverslips each inverted over a hollow-ground slide. The cultures were placed in a cold room at 0·5° C. for four hours and then incubated at 37° C. The duration of mitosis in chick tissues at 38° C. varies from 23 to 65 minutes (Levi, W. H. and M. R. Lewis, and Strangeways); at 28° C. the process takes about twice as long (Lambert and Hanes) and at lower temperatures is further delayed or arrested. Probably those cells which are in the later stages of mitosis when the culture leaves the warm incubator for the cold room pass through to completion, those in the early stages of mitosis proceed for a time and become arrested when the temperature of the culture falls to between 10° C. and 0° C. On re-incubation after chilling, the majority of these cells resume the process of mitosis. Chilling interferes with the initiation of mitosis, and there is no evidence of the resumption of this process until after 80 minutes' incubation. From this time there is a steady increase in mitosis until a maximum is reached about the 9th hour after chilling, when the number of cells in mitosis exceeds that in the controls by 60 per cent, after which there is a gradual fall up to the 13th hour of incubation. The fall in number of cells in mitosis seen during the first 5½-hour period of incubation subsequent to chilling is almost exactly compensated by the increase during the second 5½-hour period.

Vaccination of Silkworms.—Among the diseases to which silkworms are subject and which cause considerable mortality are those known as yellowness (giallume) and flaccidity. In Parts I.-V. of the *Rendiconti* of the Reale Istituto Lombardo di Scienze e Lettere for the current year, Dr. Domenico Carbone gives the results of experiments, made in conjunction with Signorina Elena Fortuna, on the vaccination of the silkworms with material prepared from the whole of the microflora of the diseased worms. Various preparations of vaccine made in different ways were employed and the mode of administration was either oral alone—by means of leaves immersed in the vaccine solution and then redried—or oral and cutaneous (spraying) together. The number of experiments made is as yet small, but the results, although not entirely consistent, indicate that distinct diminution in the mortality due to these two diseases

may be affected by the vaccination. The immunity appears to be specific.

Experimental Hop Drying.—The correct rate of drying hops is an important matter to the hop grower, since the colour and aroma by which the finished product is judged for brewing purposes are guaranteed only by prolonged and therefore expensive drying at a low temperature. More than twelve hours, for example, are required at temperatures below 120° F. The seventh season's work (1927) at the experimental oast of the Institute of Brewing, Paddock Wood, had as its principal object the determination of the most economical drying and storage conditions, and some interesting results are summarised by A. H. Burgess in the May issue of the Institute's *Journal* (**35**, 235; 1929). The actual (T) and minimum (M) times of drying in minutes were shown to be related to the loss of water (L) in oz. per square ft. of kiln floor, and the air speed (a) in ft. per min. by the equation $T = M + 87{\cdot}3\ L/a^{1{\cdot}047}$. M was found to depend principally on the temperature and to a less extent on a. Hops dried at above 104° F. showed a decrease in preservative properties, probably on account of a reduction in the proportion of so-called α-acid, though hops sterilised at 212° F. had higher preservative properties than the same hops dried in air at 140° F. Hops sterilised by treatment with sulphur dioxide, or dried in nitrogen at 212° F., however, showed a decrease in preservative value, and the effect of the former gas on the colour was no more marked than that produced by sulphur burnt in the ordinary way. The present type of intermittent kiln was shown by humidity measurements to produce very uneven drying, and a continuous type is considered more suitable. On the other hand, this lack of uniformity is partly compensated by diffusion of the moisture, particularly from the strigs to the bracts, during the cooling period.

The Coral Reefs of Oahu.—The island of Oahu in Hawaii is surrounded by a fringing reef and also shows fossil reefs in certain parts. Mr. J. B. Pollock publishes his researches on the nature and origin of these reefs in *Bulletin* 55 of the Bernice P. Bishop Museum, Hawaii. The fringing reef is in a state of active growth and is covered, like the fossil reefs up to 20 feet above sea-level, by coralline algæ and corals, the former predominating. Very few corals are found near the zone of breakers. The present fringing reef has developed since the last change in level of the sea, and began its growth at a depth of probably three fathoms or less. If the most abundant organism in the reef, a species of crustaceous alga, be taken as a basis for calculation, the rate of growth of the reef must be about 18 feet in 5000 years. Mr. Pollock insists that the study of these reefs gives no support to Darwin's subsidence theory. There is no barrier reef with lagoon. The fossil reefs were all formed during a time when the sea stood higher than it does at present, but there is no evidence by which to determine definitely their ages. The sea bottom around Oahu gives Mr. Pollock no evidence of a submarine shelf such as is demanded by the glacial control theory. Outside the reef the slope is gentle to a depth of 40 fathoms and then more rapid to 100 fathoms. He regards the slope of the sea floor as being very similar to that of the continental shelf.

Electron Waves.—The experiments of Drs. Davisson and Germer on the polarisation of electron waves, a preliminary account of which was published in NATURE last year (Nov. 24, p. 809) are described in detail in the May number of the *Physical Review*. The principle which they have employed is simple, being that of the Nörrenberg polariscope, with nickel crystals instead of mirrors, an 'electron gun' in place of the source of light, and a Faraday cylinder to receive the twice-reflected beam. The actual apparatus is most complicated, and consists of an elaborate metal structure which is built into an exhausted glass vessel, and so designed that there is freedom of motion between the appropriate component parts, whilst, at the same time, currents of only some 10^{-11} ampere to the collecting cylinder can be measured with accuracy. The assembly of the apparatus is a matter of some delicacy, and the planning and carrying out of the experiments a notable achievement. The results obtained are in agreement with Prof. C. G. Darwin's theoretical prediction that an initially unpolarised beam of electrons should remain unpolarised after diffraction by a grating, provided that the forces responsible for the scattering are electric rather than magnetic in origin.

Secondary Cosmic Radiation.—It has been noticed in work with the Wilson expansion apparatus that, even when very great care is taken to avoid radioactive contamination, fast β-rays of uncontrolled origin occasionally appear, shooting across the chamber in almost straight lines. From the small linear density of the ions in their trails, it is certain that these particles are of exceptionally high speed, and the attractive hypothesis that they represent secondary electrons produced outside of the chamber and in its walls by the ultra-gamma cosmic radiation has now been examined by D. Skobeltzyn (*Zeitschrift für Physik*, May 11, p. 686), using the method mentioned in his recent letter to NATURE (Mar. 16, p. 411). Thirty-two trails of this type appeared on making some six hundred exposures, and in only one instance was the trajectory of the particle markedly affected by the magnetic field in the chamber. The energy of the majority of the particles was not less than 15 million electron-volts. Taken in conjunction with the frequency with which they occur, and the fact that they have a predominantly vertical direction of motion, this leaves little room for doubt that they are secondary products of the cosmic radiation. The exact mechanism by means of which they are produced is nevertheless not certain. They exhibit a marked tendency to occur in groups of two or three, which are not contemplated in the usual Compton-Debye theory of the scattering of radiation, and there is also some indication that fast protons may be present, as well as the β-particles. If this can be substantiated, it will be difficult to avoid the conclusion that the cosmic rays are able, directly or indirectly, to effect the disintegration of the *nucleus* of an atom.

Specific Heats at Low Temperatures.—An account of the determination of the specific heats of acetone, methyl-, ethyl- and *n*-propyl alcohols at low temperatures is given by S. Mitsukuri and K. Hara in the *Bulletin of the Chemical Society of Japan* for March. Temperatures down to about −110° C were employed, and in order to overcome the difficulty of maintaining the environment of the calorimeter at constant temperature, a method was used whereby the temperature of the calorimeter surroundings was allowed to increase at a regular rate.

Heats of Combustion of Organic Compounds.—A critical survey of previous work on the heats of combustion of organic compounds has been made by M. S. Kharasch and is published by the U.S. Bureau of Standards in the *Journal of Research*, vol. 2, No. 2. A table of 'best' values, including all the available data, is given, together with a complete bibliography. A method is described for calculating the heat of combustion from the structural formula of the substance, and in most cases the calculated and observed values agree

to within 1 to 2 per cent, that is, within the limits of error of the experimental determinations.

Manganese in Foodstuffs.—The results of an investigation of the manganese in foodstuffs and a method for its analysis are described by Newcomb and Sankaran in the *Indian Journal of Medical Research*, vol. 16, No. 3. The ash of the foodstuff was dissolved in nitric acid and the manganese then oxidised to permanganate by ammonium persulphate in the presence of silver nitrate as catalyst. The amount of permanganate was estimated by the depth of coloration. Manganese appears to be present in all foodstuffs, with the exception of oils and cane-sugar, and a sample of oatmeal contained as much as 348 milligrams per kilogram. In cereals most of the manganese appears to be in the outer layers of the grains, and hence much of it is often removed when these are prepared for use as food.

The Radiation Hypothesis of Chemical Reaction.—If thermal unimolecular reactions are really photochemical reactions in which the frequency of the activating radiation lies within the infra-red region, then the thermal reaction rate should be increased by exposing the system to such radiation. W. Ure and R. C. Tolman have applied this test in the case of the racemisation of *d*-pinene, which is known to be unimolecular, by subjecting the pinene to radiation of wave-lengths up to 3 μ at such a temperature that the thermal reaction was just appreciable. Their experiments, which are described in the *Journal of the American Chemical Society* for April, show that large increases in the density of radiation of these wave-lengths has no effect on the rate of racemisation. The work of Lewis and Mayer, also carried out with pinene, is critically discussed, and their conclusion that radiation up to wave-lengths of 13 μ is inactive, is not accepted by Ure and Tolman.

Cracking Petroleum.—In two recent papers in the *Proceedings of the Royal Society* (vol. 116, p. 501, and vol. 120, p. 247), Prof. H. A. Wilson has developed the theory of the chemical equilibrium of mixtures of paraffins and unsaturated hydrocarbons, and has shown that the composition of both the liquid and the vapour phases can be calculated approximately if the temperature and pressure of the system are known. In a third paper, in the May issue of the *Proceedings* (p. 16), he has now applied these results to the important practical problem of the 'cracking' of petroleum, in which the composition of an oil is altered by heating it under pressure, the product being afterwards fractionated. He finds good agreement between the actual course of the reactions and that predicted from thermodynamical reasoning, both when the pressure is sufficiently high to keep the greater part of the oil in a liquid state, and when the cracking is performed on the vapour, in spite of the fact that although it is possible to make some allowance for the deposition of coke, the theory has not yet been extended to allow for the presence of naphthenes and aromatic hydrocarbons. Apart from its possible applications in petroleum technology, Prof. Wilson's work is of great interest in that it seems to confirm the view that was expressed by Berthelot so long ago as 1866, that a mixture of hydrocarbons will proceed to equilibrium if only it is raised to the appropriate high temperature.

Electric Power in Quarries.—In the *Mining Electrical Engineer* for May there is an interesting description of the Blackford quarry of the Midlothian County Council. The improved methods of quarrying, and the rapidity with which necessary repairs for the roads can now be carried out, have proved a great boon to the county. The quarry is worked by an electric supply taken from the works of the Edinburgh Corporation, and transmitted at high voltage to the quarry, where it is converted to a pressure of 400 volts. The first operation in quarrying road material is to break up the rock. This is done by the ordinary methods of drilling and blasting. The broken material is separated by hand into portions larger and smaller than about five inches. The wagons containing the material are transported by an endless rope haulage to the feeding platform, where the large material is tipped into a primary crusher, and the smaller into a shaker feed. The crusher is a massive piece of machinery with manganese steel jaws capable of reducing the material to portions not greater than five inches. The output is then transported to the secondary crushing plant. A magnetic pulley is used to prevent any 'tramp' iron from passing into the crushers and possibly damaging them. The crushers are capable of producing about 50 tons per hour, the stones all being less than $2\frac{1}{2}$ inches. By suitable screens the material is graded, some of it passing to a granulator where it is further reduced. The storage bunkers have a capacity of 800 tons each, and are divided into compartments depending on the size of the graded material. Each compartment has a sliding trap-door over the loading dock so that the material can be transferred directly to the wagons.

New Steam Tables.—An interesting report entitled "Extended Steam Tables" is made by Prof. H. L. Callendar to the Institution of Mechanical Engineers. The report is from the British Electrical and Allied Industries Research Association, with the assistance of which it recently became possible to measure the total heat of both water and steam at pressures up to 4000 lb. per square inch and temperatures up to 750° F. The need for accurate knowledge of the properties of steam at high pressures and temperatures, including the critical region, has been acutely felt recently, and this is a very welcome contribution to the subject. The new data obtained are quite inconsistent with the van der Waals theory, but fall into line with the basis of the Joule-Thompson equation. A general account is given of the theory and development of an equation of the latter type with suitable constants to give a good fit over the whole range, together with a skeleton set of tables calculated from the new equation. The equation and tables are not intended to be final, but are given as a basis for discussion and comparison. The apparatus and methods of taking and reducing the observations are dealt with briefly, since they have been fully described in previous articles dealing with investigations in lower pressure regions, to all of which articles references are made. The method of analysing the observations is illustrated by a few actual examples, the analyses chosen for this purpose being those of the observations taken with the object of investigating the effect of air and other impurities on the equilibrium between steam and water. Beyond the critical point, the effect of small impurities is very pronounced and most difficult to determine, and while this obstacle has been surmounted in this instance, the possibility readily suggests itself of great difficulty in the practical use of steam at such pressures due to instability resulting from small impurities. At low pressures the values given in the tables do not differ greatly from the previously published Callendar tables, but the differences increase with the pressure and are of considerable magnitude at the highest pressures, where the new tables tend to agree more closely with the recently published Mollier tables.

The National Physical Laboratory, Teddington.

INSPECTION BY THE GENERAL BOARD.

ON Tuesday, June 18, the General Board of the National Physical Laboratory made its annual visitation. A large number of visitors, including members of scientific and technical institutions, Government departments and industrial organisations, were present, and were received by Sir Ernest Rutherford, president of the Royal Society and chairman of the General Board, Sir Richard Glazebrook, chairman of the Executive Committee, and the Director, Sir Joseph Petavel.

Numerous experiments were in progress.

In the Aerodynamics Department the investigation on wing flutter has been extended to include the case of tail flutter, and the research has reached a stage at which recommendations can be made for the prevention or minimisation of flutter in given cases, except at flying speeds well outside the normal range. Demonstrations of the nature of wing and tail flutter were given, together with illustrations of some methods of its prevention.

The drag on an aerofoil is closely correlated with the nature of the flow close to its surface, and an experiment was in progress to determine the points at which the flow changes from a laminar to a turbulent character around a body of good aerodynamic shape. At appropriate points on the body were fitted hot wire anemometers constructed of platinum wire a few hundredths of an inch thick. In series with the anemometer wire was the primary of a transformer, and together they formed one arm of a bridge. A definite steady temperature was attained in the platinum wire with the bridge in balance. Turbulence in the boundary layer produced rapid fluctuations in the temperature, and therefore in the current through the anemometer wire, with corresponding changes in the secondary current, which was amplified by an appropriate amplifying system.

In another experiment the velocity distribution across the boundary layer was being studied at a number of points along the median section of a Joukowski aerofoil. In order to minimise external interference a very small Pitot tube is used, and can be advanced in steps of one-thousandth of an inch from outside the wind tunnel. The mechanism for advancing the Pitot head is entirely enclosed in the aerofoil, and consists of an electromagnetically operated pawl actuating a ratchet wheel attached to a finely threaded spindle passing through the Pitot tube support.

A demonstration was also given of an extreme case of body-wing interference in an aeroplane model in which the drag of the body in the presence of the wing became negative, their combined drag thus being less than the sum of their individual drags.

In the Engineering Department a machine for making tests in tension, compression, or bending up to a maximum load of twenty-five tons was shown. The machine is fitted with a six-speed gear-box, the intervals being covered by varying the speed of the driving motor. By this means rates of travel from one-thousandth of an inch to two and one-half inches per minute can be imparted to the cross-head. Autographic records of stress and strain can be taken on a recording drum.

Of interest also was apparatus for the determination of the slip and coefficient of friction of belts under running conditions. The belt passes round two large cast-iron pulleys and the sum of the tensions in the tight and slack portions can be adjusted by means of lever mechanism attached to one of the pulleys. The difference in the two tensions is obtained by means of a torquemeter on the driving shaft. The pulley speeds are measured by a speed counter connected differentially to them. From the data so obtained the belt slip and the efficiency of the power transmission can be determined.

The investigation on the mechanism of deformation in single crystals, described last year, has been extended to include the hexagonal type such as zinc and the rhomboidal type such as antimony, and it has been confirmed that deformation occurs by slip on the basal plane. Apparatus has been devised whereby Laue photographs can be taken of a single crystal of tungsten at tensile stresses up to one hundred and four tons per square inch.

For experiments on road skidding a special motor-cycle side-car has been constructed equipped with mechanism for recording the load, braking force, and force normal to the wheel, which can be set at any desired angle with the direction of motion. Records have been obtained under various climatic conditions up to speeds of about thirty miles per hour.

For the study of the deformation and fracture of metals and alloys under prolonged load at high temperatures, special apparatus has been devised in the Metallurgy Department. To enable the behaviour of the specimen to be followed during load, the surfaces must be polished and kept free from contamination. For this purpose the test-piece is enclosed in a long silica tube dipping into mercury at the bottom and communicating at the top with exhausting pumps. The mercury column which rises in the tube serves as a seal. A suitable furnace encloses the tube and specimen, temperatures of the order of 1000° C. being attained. The load is applied to the lower end of the specimen by a lever and weight. In the case of specimens which are volatile *in vacuo*, a neutral atmosphere can be introduced.

Apparatus for the determination of the heat which becomes latent in wire-drawing was shown. The wire is kept in tension by suitable springs attached to pulleys which the wire traverses. The calorimeter in which the die is placed is a Dewar flask. The work done is determined from the tensions in the springs, the difference between this and the heat generated being the latent heat of plastic deformation. An electrical method is used to measure the mean extensions of the springs, platinum-iridium contacts attached to them being free to slide along platinum wires included in two bridge circuits. The arrangement of the galvanometer and potentiometer is such that the difference between the two extensions is determined directly. The calorimeter is calibrated electrically.

Specimens of alloys for high temperature tests and of special refractories, both developed in the department, were on view. Of the former, one nickel-chromium-iron alloy containing proportions of carbon, silicon, and tungsten was found to have an ultimate breaking stress of thirty tons per square inch at 800° C., and at this temperature to withstand without breaking a steady load of five tons per square inch for 68 days.

In connexion with the determination of the metre in terms of wave-lengths of light, a new wave-length comparator is under construction in the Metrology Department. To minimise temperature effects the comparator is thermally insulated in a double walled enclosure and the room temperature is controlled thermostatically. In order to determine its tem-

perature accurately the invar end gauge about 1 metre long, which forms the Fabry-Perot étalon, is wound with its own resistance thermometer. The air in the case is heated electrically and circulated.

An interference method has also been developed of measuring the lengths of block gauges without involving the wringing of glass plates to their end surfaces. The gauge to be measured is mounted vertically in optical contact with the upper surface of a flat, horizontal steel plate. The difference in height of the two reflecting planes formed by the upper end of the gauge and the surface of the steel plate is determined in terms of light wave-lengths with reference to a lightly silvered glass plate supported above the gauge and parallel to the steel plate.

For comparing the pitches of six-inch lengths of leading screws a screw-pitch calliper has been devised in the department. The instrument rests upon the screw on two inverted V's and is fitted at each end with a ball-ended projection engaging a thread. One of these is rigidly attached to the calliper, the second being attached to one end of a lever operating a dial indicator.

In the Physics Department a distant-reading resistance thermometer outfit embodying novel features has been developed for work in connexion with the cold storage of food. The bridge is direct reading and embodies three dials giving readings in steps of 10° F., 1° F., and 0·1° F. The switch gear is so arranged that the battery current is completed only so long as one of the dial knobs is depressed. For each dial there is an appropriate resistance in the battery circuit sufficient to prevent violent deflection of the galvanometer needle if the bridge should be out of balance when the knob is depressed.

Apparatus for the determination of the latent heats of liquids at various temperatures and the specific value of refrigerants was also shown in the Heat Division. In the former the calorimeter is supported in a novel form of constant temperature enclosure consisting of a spiral of iron tubing cast into the walls of an aluminium container. The spiral is connected to a refrigerating plant circulating ammonia gas, and any desired temperature may be produced and maintained constant. The heat required for evaporation is balanced by a measured electrical supply. Liquids studied include sulphur dioxide, methyl chloride, and pentane.

In the latter apparatus two reservoirs connected by a tube and stop-valve are immersed in a constant temperature bath. One reservoir contains the liquid refrigerant to be studied and the other is connected to an evacuating system. By repeated evacuations of the latter and refilling with vapour from the liquid container, the weight of vapour required to fill the receiver can be determined, so giving the specific volume directly.

In the Sound Division apparatus for the measurement of sound absorption of materials by reverberation methods was demonstrated. The reverberation period of an empty room with hard walls is first determined, after which a definite area of the material to be tested is introduced and the period again determined. From the observed reduction in the period the absorption coefficient may be calculated. A valve oscillator and loud speaker arranged to oscillate over a definite frequency range are used to produce the sound, and a microphone, receiving set, and reflecting galvanometer serve to record the decrease in sound intensity on photographic paper, the time scale being given by an electrically operated tuning-fork and phonic motor.

Apparatus for the measurement of X-ray intensity in terms of the international unit was also shown. Normally the intensity has been measured by the colour change of barium platinocyanide pastilles when exposed to a given quantity of X-ray radiation. The accuracy of this method is limited by the sensitivity of individual observers to small colour changes and by the dependence of the reaction on the wave-length. The new apparatus consists of a rectangular ionisation chamber fitted with two parallel graphite electrodes through which the X-ray beam passes, graphite being chosen as its atomic number approximates closely to that of air. The normal guard ring is used and the potential difference across the plates is sufficient to produce saturation. A string galvanometer measures the ionisation current.

In the Optics Division a bench and measuring apparatus have been constructed for the calibration of electric lamps as master-standards of total radiation. A Moll open thermopile and potentiometer system specially designed to eliminate or minimise the effects of parasitic electromotive forces are used to determine the radiation. It is possible to compare the standards directly with a suitable black-body furnace.

In the Electric Standards Division a valve generator source of low and telephonic frequencies was shown in operation. Two oscillators are used, one possessing a fixed frequency of about one hundred thousand cycles per second, while the frequency of the other is continuously variable from about ninety to one hundred thousand cycles per second. Small voltages from each oscillator are applied to the grid of a detector valve and the resulting beat tone is amplified in three stages. The output from the final stage of amplification is very constant over a frequency range of from thirty to ten thousand cycles per second, the voltage being about one hundred.

In the High Voltage Building was to be seen apparatus which has been developed for research work on behalf of the British Electrical and Allied Industries Research Association in connexion with the dielectric losses at high voltages in power transmission cables. This apparatus consists of a large parallel plate condenser and a water-tube shielded resistor, each having zero phase angle. With these the losses in cables have been measured at voltages up to two hundred thousand. Use is made of half-wave rectification of the capacity current flowing across a spark-gap in the high voltage circuit to measure the peak voltage, which is calculated from the mean value of this current, the frequency and the known capacity of the gap.

A demonstration was given of the action of a three-phase field on a dielectric. The latter, in the form of a paper cylinder free to rotate about a vertical axis, was set at the centre of a three-phase field. The ensuing rotation of the cylinder demonstrated the presence of tangential stresses on the dielectric.

In the Wireless Division sensitive apparatus has been constructed for the rapid and accurate measurement of the capacities and power factors of condensers. A substitution method is adopted employing a condenser and series resistance in a tuned circuit, the condenser under test being substituted for a standard variable condenser. High frequency oscillations are used and the results are given in terms of the capacity of the standard condenser and the values of the resistance.

Transmitting and receiving circuits have been developed for work on wave-lengths of less than twenty-five metres. A transmitter operating at two hundred watts on a wave-length between four and ten metres, and a portable loop receiver working over the same range, were shown. Of interest also was a laboratory two-valve oscillator working on a wave-length of 1·8 metres. The inductance in this consists of a small rectangular coil the sides of which are about

an inch in length, while the capacity is provided by the inter-electrode capacities of the valves.

A single loop direction finder operating on a wavelength of seven metres is capable of receiving signals at distances up to eight miles.

In the Photometry Division improvements have been made in the apparatus for investigating the effect of glare on the brightness-difference threshold, the chief new feature being automatic control of the rate of change of brightness of the test spot. The movement of the lamp producing this spot is controlled by an electric motor, the speed of which is proportional to the distance of the lamp from the focal plane of the projection lens. This ensures constant percentage increase in unit time of the brightness-difference between the test spot and the surrounding field.

Of interest also was an investigation directed towards the prevention of fading of water-colour pigments. A sufficient range of pigments to cover approximately the visible spectrum is exposed on different fabrics to sunlight and to the radiation from a carbon arc. Protection is given by plain glass and by various types of ultra-violet absorbing glass. From the results obtained it is hoped to ascertain the best conditions for minimising the fading of water colours.

In the William Froude Tank a novel method of determining the wind resistance and centre of effort of ship superstructures by measurements in water was demonstrated. The superstructure complete with funnels, masts, derricks, etc., is towed upside down in water at slow speeds. Then, since for the same value of Reynolds's number the fraction (resistance)/(length)^2 (speed)^2 (density) is the same for air and water, the resistance in air can be determined from the measured value of the resistance in water.

Jealott's Hill Research Station.

THE future of agriculture is bound up with the development of the fertiliser industry. Farming without manures, the exploitation of the natural resources of the soil, is characterised by large areas and declining yields; it is only rendered possible by cheap and abundant labour on one hand or a high degree of mechanisation on the other. The first step towards more permanent conditions and a higher level of production is usually the fixation of atmospheric nitrogen by the agency of leguminous crops, aided when necessary by the addition of phosphate and of lime. The use of animal manures follows. Then in the search for nitrogen, farmyard manure is enriched by the feeding of purchased feeding stuffs. At this stage the need for further phosphate became insistent, and we reach the level of the best British farming of the 'seventies.

In recent years in the older countries this system has been pushed one stage further by the scarcity of land, the introduction of crops which make a great demand on the soil, and the necessity of securing a high production per acre. On the lighter soils, particularly, the need for more potash makes itself felt, and for certain crops in the rotation further nitrogen is still necessary. For a time, by-product sulphate of ammonia and Chile nitrate of soda could provide the necessary nitrogen. In the War period and the years which followed, various processes of fixing atmospheric nitrogen were greatly developed, thus laying the foundation of an abundant supply of cheap nitrogenous fertilisers in all industrialised countries.

In the meantime, numerous field experiments in Great Britain and abroad showed that an increased amount of nitrogenous fertilisers could be consumed by farmers with advantage, particularly if supported by appropriate additions of phosphoric acid and potash. It was further shown that grass-land in intensively farmed countries, which hitherto had received phosphates, if it was manured at all, could also benefit from nitrogenous fertilisers under certain systems of management. The supplying of a range of nitrogenous manures suited to the varied conditions of Great Britain and the Empire, and the working out of their economical and effective use in practice, is the task which Imperial Chemical Industries, Ltd., has taken up. As the source of supply there is the huge synthetic nitrogen plant at Billingham-on-Tees, turning out as its main products sulphate of ammonia and nitro-chalk, the former being our leading source of nitrogen as regards tonnage and range of application, with almost a century of experience and experiments behind it; the latter a new product consisting of ammonium nitrate and chalk, which combines the advantages of nitric and ammonia nitrogen. There is, however, the staff and equipment at Billingham to manufacture further products as the need for them may arise; and one may expect to see in due course the production of ammonium phosphate, and by inclusion of the natural potash salts, a range of high-grade mixed fertilisers similar to those which are becoming a feature of the continental market.

To develop the old and to investigate the new an expert agricultural service is a necessary complement to the producing organisation. Imperial Chemical Industries' Research Station at Jealott's Hill, near Maidenhead, which was opened on June 28, is designed to meet this need. It consists of a farm of some 440 acres, and a well-equipped laboratory containing the usual departments for the study of the many-sided problems of plant and animal nutrition.

The arable portion of the farm is devoted to experiments of modern design to test the effects of fertilisers on farm crops, with special reference to the use of I.C.I. products. In addition to the fertilisers mentioned above, ammonium chloride, urea, nitrate of lime, ammonium phosphate, and the German compound fertiliser 'nitrophoska', are being used. Experiments are also in view on the manuring of horticultural crops, a line of inquiry which has been somewhat neglected in the past but will assume greater importance in future. The grass-land is largely used for investigations and demonstrations of intensive systems of pasture management in which the use of generous applications of nitrogenous fertilisers is an essential feature.

This conversion of cheap inorganic nitrogen into the protein of young grass, and its further conversion into a saleable form by the agency of live stock, raises a series of practical and scientific problems which are being attacked energetically on the farm and in the laboratories at Jealott's Hill. The effect of the manurial treatment on the pasture itself from its botanical and chemical aspects is being worked out; the measurement of the digestibility of the resulting grass to various classes of stock is under investigation; while the question of how best to utilise the surplus which may arise in favourable seasons is being examined. At certain times of year, hay-making is uncertain and troublesome. Two alternative methods are being tested: the making of grass silage, and the artificial drying of short young grass, which opens up the possibility of the production of home-grown concentrates or grass cakes. The latter process, the outcome of the work of the Cambridge School,

is being followed out in detail, using experimental drying plants of various designs.

On the practical side, there are the agricultural problems which arise when any considerable change in management is made. These are being studied on the farm, and as they are successfully met they are demonstrated to visiting parties of farmers. Thus, there are demonstrations of the utilisation of intensively treated grass by young cattle (baby beef) and by dairy cows. In each case a food relatively rich in protein is required. The economic side of these trials and demonstrations is kept uppermost, and there is a special staff to work out and present this essential information.

With Jealott's Hill as a centre for direction, advice, and the examination of results, there extends a range of experimental centres and demonstration areas in Great Britain, the Empire, and in foreign countries where fertiliser tests are being made on practically the whole range of economic crops. In most cases the work is done in close co-operation with the existing official agricultural institution both at home and abroad, and it is the policy of I.C.I. to make these contacts as real as possible.

Nearly seven hundred guests representing every branch of agriculture and its related industries were present on June 28 for the official opening of the Research Station by the Right Hon. J. H. Thomas, Lord Privy Seal. The weather conditions were ideal, and the arrangements for the comfort of the visitors were admirably carried out. The importance of agricultural research in Great Britain and in the Empire, and the part which the new research station is to play in this sphere, were set out by the chairman, the Right Hon. Lord Melchett, and by other directors of Imperial Chemical Industries, Ltd.

The Jealott's Hill Station will take up its work with the good wishes of the other institutions already established in the field of agricultural research.

H. V. GARNER.

University and Educational Intelligence.

BIRMINGHAM.—At a degree congregation held on June 29 the following degrees were conferred: D.Sc. (chemistry) on Mr. E. L. Hirst; M.D. on Mr. W. D. Beck and Mr. C. G. Payton. For the degree of Ph.D. in science there were six successful candidates.

LIVERPOOL.—A further step towards the completion of the School of Veterinary Science of the University was taken on June 28, when the new Veterinary Hospital was formally opened by Lord Howard de Walden in the presence of a representative gathering of those who have striven during the past twenty years for fuller facilities for veterinary research and the care of animals. This is the first occasion on which such an hospital is to be conducted by a university in Great Britain. The building is of quadrangle form, and surrounds a central court with glass roof. There is an operating theatre for large animals, and ample accommodation has been provided in the form of animal boxes and stalls. In addition there is a lecture theatre, and a museum, laboratory, operating theatre, and a surgical ward have been provided, the latter being specially designed for the needs of small animals. There is also accommodation for a resident surgeon and his staff. The institution is intended primarily for research and instruction, but in all probability provision will be made for the treatment of domestic pets belonging to the poor. Mr. R. Isherwood, lecturer in veterinary medicine and honorary lecturer in clinical veterinary medicine and surgery, has been appointed administrator of the hospital, and will be associated with Profs. Share Jones and Gaiger in its direction.

ST. ANDREWS.—On Friday, June 28, Her Royal Highness the Duchess of York opened the new Graduation Hall, the gift of Mr. James Younger, of Mount Melville, Chancellor's Assessor in the University Court, and Mrs. Younger. The building is in North Street to the east of the College Chapel, and is capable of seating an audience of more than 1200 persons. The original designs prepared by Mr. Paul Waterhouse, who died in 1924, were carried out by his son, Mr. Michael Waterhouse. The actual cost, amounting to about £95,000, has been met entirely by Mr. and Mrs. Younger. Her Royal Highness, after declaring the Hall open and handing the deed of gift to the Vice-Chancellor, Sir James Irvine, was presented for the honorary degree of doctor of laws. Among the honorary graduates who were afterwards capped were Lord Blanesburgh of Alloa, and Profs. John Dewey of Columbia University, T. Percy Nunn of the London Day Training College, and A. E. Taylor of Edinburgh.

THE Joint Committee of the Royal Society and the University of Sheffield has appointed Dr. W. H. George to the Sorby Research Fellowship, tenable at the University of Sheffield. Dr. George will continue his work, begun at the Davy-Faraday Research Laboratory, at the Royal Institution, on X-rays and crystal structure.

APPLICATIONS are invited for the Drapers Company's research scholarship in dyeing, value £100 a year with remission of fees; the Joseph Blamires research scholarship for research in colour chemistry, value £100 a year with remission of fees; and the British Dyes research scholarship for research in colour chemistry, value £75 a year with remission of fees. Particulars and forms of application may be obtained on application to the Director of Education, Technical College, Huddersfield.

THE Air Ministry announces that six hundred aircraft apprentices, between the ages of fifteen and seventeen years, are required by the Royal Air Force for entry into the Schools of Technical Training at Halton, Bucks, and at Cranwell, near Sleaford, Lincs. They will be enlisted as the result of an open competition and of a limited competition which will be held by the Civil Service Commissioners and the Air Ministry respectively. Full information regarding the dates of the respective examinations, the methods of entry and the aircraft apprentice scheme generally can be obtained from the Royal Air Force, Gwydyr House, Whitehall, S.W.1. The scheme offers an opportunity to well-educated boys of obtaining a three years' apprentice course of a high standard.

A KING Senior Medal, consisting of a gold medal, has been founded by Mr. Sontsu G. King in memory of his parents, Mr. and Mrs. Sung-yuan Daw King, with the object of encouraging original investigations in natural history. The medal is to be awarded annually for the most meritorious work, selected by a prize committee appointed by the executive council of the Peking Society of Natural History, on the flora or fauna of China. Mr. King has also founded a King Junior Prize, consisting of a bronze medal and the sum of 20 dollars local currency, in memory of his brother, Mr. Kung-pao King, a charter member of the Peking Society of Natural History, to be awarded for the best collection of Chinese natural history objects with descriptive notes made by anyone under twenty years of age.

Calendar of Patent Records.

July 6, 1846.—One of the most common proposals for achieving perpetual motion has been to mount weights on a wheel in such a manner that they are free to move towards the periphery on the descending side of the wheel and towards the centre on the ascending side, the greater leverage thus given to those on the descending side serving, it is assumed, to produce the rotation of the wheel. James Thompson's invention, for which a patent was granted on July 6, 1846, utilises this principle to increase the power of a steam-engine, two oppositely disposed levers being fixed to the fly-wheel shaft, which are acted on by weights moved to and fro along the levers by crank motions.

July 7, 1856.—'Condy's fluid', a mixture of sodium manganates and permanganates, was the invention of Henry Bodman Condy and was patented by him on July 7, 1856.

July 7, 1884.—The first International Convention for the protection of industrial property was signed at Paris in 1883, and came into force on July 7, 1884. Its main provision allowed an inventor who had applied for a patent in any one of the signatory States to obtain a patent for the same invention in priority to other applicants in any other country of the union, protection to start from the date of the first foreign application. The International Union now comprises 42 States, including the self-governing dominions of the British Empire; Russia is the most notable exception.

July 8, 1876.—Blasting-gelatine—a mixture of nitroglycerine with 7-8 per cent of collodion gun-cotton—was invented by Alfred Nobel in 1875 and was patented by him in Sweden on July 8, 1876. The English rights were transferred under an old agreement to the Nobel Explosives Co., of Ardeer, but production of the new explosive did not start here until 1879, and large quantities were imported into Great Britain from the continent, where the manufacture had been very rapidly developed.

July 10, 1817.—The kaleidoscope was patented by David Brewster on July 10, 1817: "A new optical instrument called the kaleidoscope, for exhibiting and treating beautiful forms and patterns, of great use to all the ornamental arts—realising the idea of an ocular harpsichord".

July 12, 1799.—An invention for utilising the force of the waves of the sea was patented in France on July 12, 1799, by the Girards, father and son, of Paris. A float in the water is suspended from one end of a lever, the other end of which operates pumps, wheels, or mills. Or a boat is provided with gearing which is operated as the boat rises and falls by a rope, one end of which is anchored to the bottom of the sea and the other end weighted.

July 12, 1848.—An early electric incandescent lamp was patented by W. E. Staite on July 12, 1848, the filament being of platinum and iridium and operating in the air. Staite was also the inventor in 1846 of an arc lamp having two vertical carbons, the upper one of which was stationary and the lower one actuated by clockwork under the control of an electromagnet in the lamp circuit, so that the carbon was moved up and down as required.

July 13, 1781.—The compound steam-engine was first introduced by Jonathan Hornblower, whose patent for the invention was dated July 13, 1781. An engine was erected at the Tin Croft mine in Cornwall in 1792, but was found to give no greater efficiency than the Watt engine, and the experiment was abandoned. It was many years, in spite of its reintroduction by Wolff in 1804, before the principle of compounding was fully developed.

Societies and Academies.

LONDON.

Royal Society, June 27.—**Lord Rayleigh**: A photo-electric method of measuring the light of the night sky: with studies of the course of variation through the night.—**J. C. McLennan, M. W. Perrin, and H. J. C. Ireton**: The action of high-speed cathode rays on acetylene.—**Lord Rayleigh**: Fluorescent and phosphorescent excitation of mercury vapour by the resonance frequency and lower frequencies.—**T. E. Stern, B. S. Gosling, and R. H. Fowler**: Further studies in the emission of electrons from cold metals. An extension of Nordheim and Fowler's work on electronic emission from clean cold metals. It explains a wide range of experimental results obtained with films of sodium (or tungsten). The normal stable sodium film formed is mono-molecular and reduces the work function from 4·5 volts to somewhat less than 2 volts. The currents concerned are of high density; the space charge correction is negligible for the conditions of the experiments discussed.—**A. E. H. Love**: The stress produced in a semi-infinite solid by pressure on part of the boundary. The method of potentials, invented by Boussinesq, is developed and applied to the case of uniform pressure over a circular area, among others. The solution is also discussed arithmetically with the object of throwing light on the technical question of the safety of foundations. Beneath a round pillar, there is a basin-shaped surface possessing a roughly similar property. The form of this surface is determined. In these cases failure arises through excessive stress-difference. Tensile stress is greatest near the base of a pillar, or a corner of the base of a wall, and just outside it. It would not endanger a round pillar, but may be a cause of decided weakness if the boundary of the base of a wall or pillar presents a sharp corner.—**A. N. Shaw and H. E. Reilley and R. J. Clark**: The ageing of standard cells: increased accuracy in their use: and international comparisons.—**H. Quinney**: A comparison between the behaviour at the Ac_3 point of single crystal iron and polycrystal iron, both in the strained and unstrained states.—**J. N. Pring and G. M. Westrip**: An electrometric method for the determination of ozone at high dilutions.—**C. F. Jenkin and G. D. Lehmann**: High-frequency fatigue.—**J. S. Townsend and S. P. MacCallum**: Ionisation by collision in monatomic gases. A discussion of some recent theories of conductivity.—**R. C. Johnson and R. K. Asundi**: The structure of the high-pressure carbon bands and the Swan system. Both systems are due to a C_2 molecule. Four new high-pressure bands have been found in the near ultra-violet, and two more in the near infra-red. These, with the known bands, form a single vibrational progression ($n' = 0$), and both systems represent transitions to a common final state. The initial state of the high-pressure system is believed to be a *normal* ^3P level and different in this respect from the two lower ^3P levels, which are believed to be *inverted*.—**D. M. Newitt**: Gaseous combustion at high pressures (13). The experimental data from explosions of various $2CO + O_2 + 4CO$, $2H_2 + O_2 + xN_2$ and $2H_2 + O_2 + xA$ mixtures at high initial pressures have been analysed, and mean molecular heats of nitrogen and steam have been calculated for the temperature range 289°—2600° to 3000° K and for carbon dioxide for the range 289°—3173° K. The results for nitrogen are in agreement with the generally accepted values, but those for steam and carbon dioxide are higher.—**R. J. Clark**: On the direct determination of the electrostatic moments of molecules. Direct deflection in a rapidly varying field is used. Sodium and potassium atoms

have either no permanent electric moment, or one that is too small to measure. So far no polarisation by the field on these molecules has been found.—**A. R. Low**: On the criterion for stability of a layer of viscous fluid heated from below. Rayleigh gave a mathematical account of the modes of instability of a viscous fluid heated from below with the special assumption of zero tangential forces at the boundaries, and found unexpectedly that the top-heavy layer of fluid was stable until a certain temperature gradient, negative upwards, was exceeded. Jeffreys has reduced the problem to the solution of a linear differential equation of the sixth order with constant coefficients, the complete solution of which is now given.—**R. B. Brode**: The absorption coefficient for slow electrons in mercury vapour.—**F. L. Usher**: A mechanism of gelatinisation.—**H. R. Hassé** and **W. R. Cook**: The determination of molecular forces from the viscosity of a gas.—**J. C. McLennan, A. B. McLay**, and **M. F. Crawford**: The spark spectrum of thallium (Tl III).—**R. A. Fisher**: Tests of significance in harmonic analysis.—**F. H. Constable**: Sulphide colours on metallic copper. Spectrophotometric methods show that the sequence of colours produced when a mixture of hydrogen sulphide and air or oxygen acts on metallic copper is a series of true interference colours. The characteristic silvery colour is due to the flatness of the reflection maximum in the intensity wave-length curve.—**G. I. Taylor**: Waves and tides in the atmosphere.—**R. W. B. Pearse**: The ultra-violet spectrum of magnesium hydride II. The bands of the many-lined ultra-violet (γ) system of magnesium hydride have been measured in the region λ 2560 to λ 3240. The vibrational analysis shows that this system has no level in common with the previously known α- and β-systems. The rotational structure is that characteristic of the $^1S \rightarrow {}^1S$ type of electron transition. Measurements of the isotope effect in two of the bands indicate that the emitter is the diatomic molecule MgH (or MgH^+), Mg having isotopes of atomic weights 24, 25, and 26.—**G. Temple**: The second-order wave equations of the spinning electron. The equations are obtained by a simple modification of Maxwell's electrodynamic equations. As in Dirac's theory, non-commutative properties of the operators are employed to introduce spin-correction terms into the wave-equations and expressions are obtained for charge-density and current-density, together with polarisation and magnetisation.—**A. V. Hill**: Anaerobic survival in muscle.

Physical Society, May 24.—**J. H. Vincent**: Experiments on magnetostrictive oscillators at radio frequencies. An account is given of the behaviour of two magnetostrictive oscillators, 6 mm. and 4·5 mm. in length, when placed in a coil in series with the main induction coil of a simple valve-maintained oscillating circuit. The frequency characteristic of the smaller oscillator is 540 kc./sec.

June 14.—**W. Jevons**: The band spectrum of lanthanum monoxide: with a preliminary note on electronic band spectra of diatomic molecules. The spectrum has been observed from λ8700 to λ2850, and the band-heads (most of them not hitherto recorded) arranged into several systems.

PARIS.

Academy of Sciences, May 27.—**Ch. Lallemand** and **E. Prévot**: Slow variations of the mean level of the sea on the French coast. The rise in the sea-level, verified on the French coast for the last three-quarters of a century, is not due, as had been supposed, to a slow sinking of the ground, but to astronomical phenomena of a periodic nature. The total amplitude of the regular oscillation appears to be about 7·5 cm.—**H. Vincent**: The therapeutic results given by a new antistreptococcic serum. Detailed account of clinical results obtained with the new serum.—**André Blondel**: The powers and mutual *hormanances* of non-sinusoidal alternating currents. Suggestion of a new terminology for wattless currents.—**E. Mathias**: Contribution to the study of fulminating material. Discussion of the best means of protecting buildings against globular lightning.—**J. Neyman**: The limit of probability of hypothesis.—**Paul Dubreil**: Some complements to Nœther's theorem.—**Serge Bachvaloff**: The simultaneous deformation of two associated surfaces.—**S. Finikoff**: The congruences of Goursat.—**Georges Durand**: The construction of Cantor-Minkowski in the plane.—**Miron Nicolesco**: A theorem of Pompeiu.—**René Lagrange**: Certain functions associated with Legendre functions.—**Henri Cartan**: The growth of meromorph functions of one or more complex variables.—**J. Le Roux**: Systems of reference with apparent gravitation.—**H. Mineur**: Statistical researches on the solar apex and on the vertex of the distribution of the stellar velocities.—**Alex. Véronnet**: The electronic theory of the ether and of light. The electronic theory, extended to the ether, explains the field not mechanically but electrically. From this theory can be deduced the laws of light, magnetism, and gravitation.—**V. Bjerknes**: The equations of hydrodynamics.—**J. E. Verschaffelt**: Can the Maxwell-Clausius relation be explained without recourse to the principle of Carnot? Critical discussion of a recent communication (*C.R.* 1929, p. 778) of V. Karpen.—**L. Brüninghaus**: The existence of a conducting state of so-called insulating liquids. Certain liquids (petrol, vaseline oil, crystallised benzene) in thicknesses of the order of 0·5 mm. show a slight conductivity, diminishing with time: this may be attributed to the presence of traces of dissolved water. But for thicknesses of the order of 10 μ a new phenomenon appears. Under a potential difference of from 50 to 110 volts, these insulating liquids suddenly acquire metallic conductivity. The possibility of a short circuit was excluded and there was no pulverisation of the metal.—**Pierre Bricout**: The efficacity of discontinuous electrostatic screens.—**G. Sładbei**: A new use for piezo-electric quartz. An application to chronometry.—**Edmond Rouelle**: The characteristics and stability of ferroresonant circuits (oscillating circuits admitting of coils with iron cores).—**Jean Thibaud**: The possible existence of important exceptions to the principle of selection relative to the total quantic number. The N spectrum of thorium.—**A. Canaud**: The electrolysis of water with alternating current. The hydrogen produced is taken as a measure of the electrolysis. The results of experiments with solutions of potassium, calcium, magnesium, and sodium sulphates are given.—**A. Roux** and **J. Cournot**: The study by means of the X-rays of the internal transformations of the silver-zinc alloys. The effects of annealing, tempering, and reheating after tempering were specially studied: the general conclusions given in an earlier communication, based on physical and micrographic measurements, were confirmed.—**S. Rosenblum**: The fine structure of the magnetic spectrum of the α-rays of thorium *C*. Use was made in these experiments of the large electromagnet of the Academy of Sciences giving a magnetic field of the order of 36,000 gauss.—**M. Prettre** and **P. Laffitte**: The temperatures of ignition of mixtures of carbon monoxide and air. The precautions taken were the same as those described in a previous paper for mixtures of hydrogen and air. The ignition temperature is not modified by the presence of small proportions of residual burnt gases, but is lowered to

a marked extent by water vapour.—J. Bougault and J. Leboucq: The action of heat on the allophanic amides. The decomposition by heat (200°-210° C.) of the allophanic amides derived from amines of the aniline type gives ammonia, cyanuric acid, and a symmetrical urea. The allophanates derived from hydrazines behave differently, there is no formation of cyanuric acid, ammonia is produced and there is condensation to a urazol.—R. Bousset: The problem of asymmetric synthesis.—Lespieau and Journaud: 1 : 6-Heptadiine and 1 : 8-nonadiine. These two hydrocarbons are produced by the interaction at ordinary pressure of the sodium derivative of acetylene and trimethylene bromide and pentamethylene bromide respectively. The physical and chemical properties of the two hydrocarbons are given.—Mme. Pierre Billon-Bardon: The reduction of diphenylglycidic ether by means of sodium and absolute alcohol.—Henri Moureu: The tautomerism of the α-diketones: Study of the states of equilibrium. Methylbenzylglyoxal can be obtained in two tautomeric forms differing markedly in their refractive indices. Starting with either of these, the equilibrium in the presence of a catalyst can be studied by means of the refractive index. The results of the experiments, shown graphically, prove that the same equilibrium point is reached whichever isomer be taken.—A. Leulier and Y. Dreyfuss: The bromination of 1 : 4-aminophenylarsinic acid.—R. Fosse, A. Brunel, and P. De Graeve: The quantitative biochemical analysis of allantoin in the presence of urea. Hydrolysis is carried out by means of *Soja hispida*, in presence of ammonium carbonate. The urease destroys the urea and the allantoinase converts the allantoin into allantoic acid.—Edgar Aubert de la Rue: The existence of agate and of Iceland spar in the Kerguelen Archipelago.—Jacques Bourcart and Guy Le Villain: The Acadian of the Moroccan Antiatlas.—A. Demay: The Moldanubian (Hercynian chain).—A. Perrier: The presence of certain thermophile fungi in farmyard manure and in organic matter undergoing decomposition. A fungus with optimum temperature of growth 40° C. which resists a prolonged exposure to 55° C. is termed thermo-tolerant, reserving the word thermophile for moulds the optimum culture temperature of which is above 50° C. One such mould has been isolated with an optimum culture temperature of 57°-60° C. and resisting several hours' exposure to 72° C.—V. Ghimpu: Contribution to the chromosome study of the Acacia.—G. Mangenot: The so-called phenomena of aggregation and the arrangement of the vacuoles in conducting cells.—A. Sartory, R. Sartory, and J. Meyer: A disease of the melon (*Citrullus vulgaris*) caused by a Fusarium and a colour-producing bacterium.—R. Bonnet and Tchang-Hyao-Tchi: Overfeeding. Experiments on giving a considerable excess over the normal food ration to the rabbit and the pigeon. It was shown that the alimentary canal acted as a regulator of the energy distribution.—Emile F. Terroine and P. Danmanville: The formation of creatine at the expense of proteid substances.—Michel Polonovski and René Hazard: The comparative cardiovascular actions of two isomers: tropanol and pseudotropanol.—A. Fessard and H. Laugier: The form of the electromyogram of voluntary contraction. Oscillographic records.—Robert Faillie and Martinot Lagarde: Study of the influence of lighting on the precision of movements in the course of professional work. Three different tests were applied to five subjects, and the mean results are given as curves. These show that for feeble illumination a small increase in the light intensity produces a marked improvement in the precision of the movements.—H. Colin and P. Ricard: Some properties of laminarine from the Laminaria.—Paul Cristol: The interpretation of the values for the alkaline reserve of the blood plasma in the course of the keto-acidoses. In the case of keto-acidosis, normal or high alkaline reserves, frequently met with in diabetes, should be regarded as results due to defective technique; the accumulation of acetylacetic acid in the blood causes errors in the analytical method of Van Slyke.—J. Vellard and Miguelote Vianna: Modifications of the blood coagulation in yellow fever: their importance for the early diagnosis.—A. Saenz: The transplacental infection of the guinea-pig by the ictero-hæmorrhagic spirochæte.

COPENHAGEN.

Royal Danish Academy of Science and Letters, Jan. 25.—C. Wesenberg-Lund: Contributions to the biology of *Leukochloridium paradoxum*. This peculiar Trematod larva, living in *Succinea putris*, has been studied for four years, partly in Nature and partly in cultures, some of which are more than four years old.

Feb. 8.—P. O. Pedersen: Long retarded echo signals. Discussion of the possibility of obtaining long retarded echo signals of the propagation of radio waves within the terrestrical atmosphere, or by reflection from or by propagation along ionisation bands outside this atmosphere.

Feb. 22.—Ojvind Winge: The nature of the sex chromosomes in *Humulus*. The male plant of *Humulus Japonicus* has three X-chromosomes, while the female has two. The difference between the two sexes, thus, is of quantitive nature. In *H. lupulus* the male has one X- and one Y- and the female two X-chromosomes, the Y-chromosomes of the male plant being homologous with the two X-chromosomes of *H. Japonicus*.

Mar. 8.—Elis Strömgren: Some classes of orbits in the restricted problem of three bodies (problème restreint). In 1889 and 1892 the Danish Academy set two prize questions, which resulted in the first attempts (v. Haerdtl and Burrau) to solve with the aid of numerical integration such special cases of the problem of three bodies as are not pure problems of perturbation. In 1897 G. H. Darwin published his well-known paper "Periodic Orbits", in which some classes of periodic orbits in the special problem, the "Problème restreint", were studied. In 1913 the problem was again attacked at the Copenhagen Observatory, and the programme—the study of all simple periodic orbits in the problème restreint—has now been carried through. The present paper gives the numerical results for some of the classes of orbits. The whole numerical material is to be published.

Mar. 22.—Harald Bohr und Börge Jessen: The distribution of the Riemann ζ-function (1).—C. H. Ostenfeld: A fertile interspecific hybrid in the genus *Polemonium*. *P. mexicanum* and *P. pauciflorum* are two Mexican species, the former rather a slender plant with short blue corollas and transparent tube about 3·5 mm. in length, the latter a coarser plant with fewer and larger flowers, yellowish corolla with reddish tinge and tube about 30 mm. long. *P. mexicanum* ♀ × *P. pauciflorum* ♂ gives an intermediate and uniform F_1, which splits in F_2 and F_3 and is fertile. The reciprocal cross fails, probably because the pollen of *P. mexicanum* is not able to grow down the stigma of *P. pauciflorum* to its ovary.

April 19.—L. Kolderup Rosenvinge: Reproduction in the Danish species of *Phyllophora*. The nemathecium of *Phyllophora Brodiæi* does not belong to a parasite (*Actinococcus*), and it is not an organ of the *Phyllophora*-plant; it arises on a sporophyte, developing in the sexual shoots from the auxiliary

cell of a procarp, breaks through the surface of the plant and produces nemathecia. On germination, the tetraspores of the latter give rise to young plants of *Phyllophora*. The nemathecia of *Phyllophora rubens* are true organs of the species.

May 5.—**C. H. Ostenfeld**: The species of larch (*Larix*) and their geographical distribution. All the species are found on the northern hemisphere and are, as a rule, mountain plants; towards the north some of them occur at the sea-level. Three of the ten species occur in North America, the others in Eurasia. Most of them have restricted areas of occurrence; only *L. sibirica*, *L. dahurica*, and *L. laricina* are widespread. The distribution of the various species is given.

GENEVA.

Society of Physics and Natural History, Mar. 21.—**G. R. Gutzeit and Ch. Devaud**: A new automatic apparatus for titration. The apparatus is based on the fact that the potentiometric curve of the liquid in which the reaction takes place presents a sharp minimum at the neutral point, in the case of a strong acid and a strong base. The arrangement, which also includes automatic filling of the graduated burette, is such that the titration is automatically stopped at the neutral point.—**E. Briner, P. Schnorf, and R. Meyer**: The ozonation of the gaseous unsaturated hydrocarbons. The authors have specially studied the ozonation of those unsaturated hydrocarbons (ethylene, propylene, butylene), which are present in industrial gases (lighting gas, coke oven gas, gas from oil cracking). These substances have been submitted to ozonisation, either in solution at a low temperature, with the view of the production and study of the ozonides, or in the diluted gaseous state in the presence of more or less steam, which removes all danger of explosion. The yields recorded for the utilisation of ozone and these hydrocarbons are sufficiently high to give a technical interest to the problem studied.—**Ed. Parejas**: Geological observations in Corsica (4). Details of the Lias of Corte and the autochtone nummulitic of Lozari. The author notes the presence in the "brèche du Télégraphe" of Corte of limestone bands associated with carbonaceous deposits. These facies are identical with those of the zoned limestones of the middle Lias of the Chamonix region. The autochtone Lutecian of Lozari extends to the north of the sea; it is there represented by a coarse grit containing *Nummulites perforatus* and *Discocyclina Archiaci*.—**E. Rod and G. Tiercy**: The eclipse of the sun of Nov. 1, 1929, at Geneva. The times of first and last contact have been calculated graphically; the first contact will take place at 11.16, Geneva civil time, the last contact at 13.8. The middle of the eclipse will be at 12.12. At this time 0·18 of the sun's diameter will be covered by the moon. Hence at Geneva the eclipse will not be very noticeable.—**G. Tiercy**: Where astronomers and navigators do not appear to have been happy in the choice of a term. The author recalls that astronomers and navigators often consider the terms 'correction' and 'rate' (*état*) of a clock as having the same meaning. In reality 'correction' and 'rate' have opposite signs, where the word rate (*état*) has the usual signification given to it in the ordinary language of business, finance, physics, etc. This confusion appears to arise from the fact that astronomers have called the *marche* of a chronometer the difference between two successive corrections ($\text{correction}_1 - \text{correction}_2$), whilst in ordinary language the course of any enterprise is the difference between two successive rates ($\text{rate}_1 - \text{rate}_2$); the latter mode of expression is that generally employed by clockmakers.

MELBOURNE.

Royal Society, April 11.—**C. H. Ostenfeld**: A list of Australian sea-grasses. As a result of the examination of the National herbaria of New South Wales and Victoria and of some recent collections from the eastern States, several interesting additions to the knowledge of the distribution of the sea-grass flora of Australia are listed.—**Isabel C. Cookson**: An account of a crown rot of English walnut trees in Victoria. A crown rot of English walnuts has occurred spasmodically for some years in the north-eastern district of Victoria, the casual organism has been found to be a species of *Phytophthora*, compared by the writer with *P. parasitica* Dastur. It is an intercellular parasite occurring in the phlœm and cambial regions, causing the death of these tissues, and a subsequent separation of the wood and bark. The parasite has been isolated in pure culture, and its life history followed. When inoculated into seedling walnuts, death has resulted, and from their dead tissues the fungus has been re-isolated.

Official Publications Received.

BRITISH.

Wigan and District Mining and Technical College. Opening of Extension by the Rt. Hon. the Viscount Chelmsford, 13th June 1929. Pp. 14+9 plates. (Wigan.)

Journal of the Indian Institute of Science. Vol. 12A, Part 6: i. A Study of the Symbiotic Fungus from the Mysore Lac Insect, by M. Sreenivasaya and S. Mahdihassan; ii. The Golgi Apparatus of Free-living Protozoa, by H. S. Madhava Rao. Pp. 69-77 + 3 plates. (Bangalore.) 12 annas.

University of Sheffield. Experimental Researches and Reports published by the Department of Glass Technology. Vol. 11, 1928. Pp. iii+203. (Sheffield.)

Northamptonshire Education Committee. Land Utilization Map of the County of Northampton: prepared from a Parish Survey on the Six-Inch Scale, carried out by the Pupils of the Public Secondary and Elementary Schools of the County, under the supervision of their Teachers. E. E. Field, Controller of the Survey. Scale of One Inch to One Statute Mile. In 3 Sheets. 33½ in. × 25½ in. (Northampton: County Education Offices.)

Ceylon Journal of Science. Section B: Zoology and Geology. Spolia Zeylanica. Edited by Dr. Joseph Pearson. Vol. 15, Part 2, May 20th. Pp. 73-168 + plates 21-34. (Colombo: Colombo Museum; London: Dulau and Co., Ltd.) 2.50 rupees.

Malaria in Forest Areas. By Lieut.-Col. J. A. S. Phillips. Pp. 26. (Calcutta: Government of India Central Publication Branch.) 2 annas; 3*d*.

Transactions of the Mining and Geological Institute of India. Vol. 23, Part 2, May. Pp. 91-194+plates 2-10. (Calcutta.) 2.8 rupees.

Mining and Geological Institute of India. Member List, 1929. Pp. 26. (Calcutta.)

The Indian Forest Records. Silvicultural Series, Vol. 13, Part 9: Commercial Timber (Katha) and Heartwood Volume Tables for Khair (Acacia Catechu, Willd.) in North India. By H. G. Champion, Ishwar Das Mahendru and Parma Nand Suri. Pp. 33+2 plates. (Calcutta: Government of India Central Publication Branch.) 14 annas; 1*s*. 6*d*.

Administration Report of the Marine Biologist for 1927. Pp. 27. (Colombo: Government Record Office.) 65 cents.

Administration Report of the Director of the Colombo Museum for 1927. Pp. 35+9 plates. (Colombo: Government Record Office.) 1 rupee.

Loughborough College, Leicestershire. Calendar, Session 1929-30. Pp. xiv+234+75 plates. (Loughborough.) 2*s*. 6*d*. net.

Department of Scientific and Industrial Research. Building Science Abstracts. Compiled by the Building Research Station and published in conjunction with the Institute of Builders. Vol. 2 (New Series), No. 5, May. Abstracts Nos. 825-1025. Pp. v+173-206. (London: H.M. Stationery Office.) 9*d*. net.

University of Cambridge: Department of Agriculture. Animal Nutrition Research Institute. First Report on the East Anglian Pig Recording Scheme. By H. R. Davidson and A. N. Duckham. Pp. 48. (Cambridge.) 1*s*. net.

Ventilation Conditions, Normal and Abnormal: and their Investigation. By Robert C. Frederick. Pp. 36. (London: Institute of Chemistry.)

Transactions of the Royal Society of Edinburgh. Vol. 56, Part 2, No. 12: A Study of the Effect of Diurnal Periodicity upon Plant Growth. By George Redington. Pp. 247-272+2 plates. 4*s*. Vol. 56, Part 2, No. 13: Jurassic and Kainozoic Corals from Somaliland. By Mary H. Latham. Pp. 273-290+2 plates. 3*s*. (Edinburgh: Robert Grant and Son; London: Williams and Norgate, Ltd.)

Trinidad and Tobago. Minutes and Proceedings of the Froghopper Investigation Committee. Part 1. Pp. 23. Part 2. Pp. 25-39. Part 3. Pp. 41-59. Part 4. Pp. 61-98. Part 5. Pp. 99-140. Part 6. Pp. 141-177. Part 7. Pp. 179-210. Part 8. Pp. 211-258. Part 9. Pp. 259-306+1 plate. Part 10. Pp. 307-351. Part 11. Pp. 35. Part 12. Pp. 37-112. Part 13. Pp. 113-173. Part 14. Pp. 175-222. (Trinidad, B.W.I.: Government Printing Office.)

Journal of the Chemical Society: containing Papers communicated to the Society. June. Pp. iv+1109-1385+viii. (London.)

Air Ministry: Aeronautical Research Committee. Reports and Memoranda. No. 1201 (E. 29): On the Stiffness of Crankshafts. By H. Constant. (I.C.E. 670; T.V.C. 46; Final revise.) Pp. 16+8 plates. 1s. net. No. 1213 (Ae. 372): Wind Tunnel Tests of Aerofoils with Pilot Planes. By F. B. Bradfield and K. W. Clark. (T. 2717.) Pp. 26+10 plates. 1s. 3d. net. (London: H.M. Stationery Office.)

FOREIGN.

Contributions to Embryology. Vol. 20, Nos. 109-117: Early Stages in the Development of Pig Embryos, from the Period of Initial Cell Cleavage to the Time of the Appearance of Limb-Buds, by C. H. Heuser and G. I. Streeter; The Development of the Meninges in Amphibia, a Study of Normal and Experimental Animals, by Louis B. Flexner; On the Placentation of Primates, with a Consideration of the Phylogeny of the Placenta, by George B. Wislocki; A Well-preserved Human Embryo of 10 Somites, by George W. Corner; The Topographic History of the Volar Pads (walking Pads; *Tastballen*) in the Human Embryo, by H. Cummins; A Correlated Study of the Development of Reflex Activity in Fetal and Young Kittens and the Myelinization of Tracts in the Nervous System, by Orthello R. Langworthy; The Effect of various Solutions and Salts upon the Pulsation Rate of Isolated Hearts from Young Chick Embryos, by Warren H. Lewis; Macrophages and other Cells of the Deep Fascia of the Thigh of the Rat, by Warren H. Lewis; The Technique of measuring the Outer Body of Human Fetuses and of Primates in General, by Adolph H. Schultz. Pp. iii+257+52 plates. (Washington, D.C.: Carnegie Institution.) 5.50 dollars.

Publikationer og mindre Meddelelser fra Københavns Observatorium. Nr. 63: Fortsetzung und Abschluss der Librationen um L_2 und L_3 im restringierten Dreikörperproblem (Problème Restreint). Von Elis Strömgren. Pp. 46+1 tafel. (København.)

Forty-third Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1925-1926. With Accompanying Papers—The Osage Tribe: Two Versions of the Child-naming Rite, by Francis La Flesche; Wawenock Myth Texts from Maine, by Frank G. Speck; Native Tribes and Dialects of Connecticut, a Mohegan-Pequot Diary, by Frank G. Speck; Picuris Children's Stories, by John P. Harrington and Helen H. Roberts; Iroquoian Cosmology, Second Part, by J. N. B. Hewitt. Pp. vii+828+44 plates. (Washington, D.C.: Government Printing Office.) 2.75 dollars.

Proceedings of the American Academy of Arts and Sciences. Vol. 63, No. 12: Records of Meetings, 1927-1928; Biographical Notices; Officers and Committees for 1928-1929; List of the Fellows, Associates and Foreign Honorary Members; Statutes and Standing Votes; Rumford Premium; Index. Pp. 439-524+iv. (Boston, Mass.) 50 cents.

Conseil Permanent International pour l'Exploration de la Mer. Rapports et Procès-verbaux des Réunions. Vol. 56: Whales and Plankton in the North Atlantic; a Contribution to the Work of the Whaling Committee and of the North Eastern Area Committee. Pp. vi+123+26+29+70+50+112+57+84. (Copenhague: Andr. Fred. Høst et fils.) 21.50 kr.

Proceedings of the United States National Museum. Vol. 73, Art. 20: The Florida Tree Snails of the Genus Liguus. By Charles Torrey Simpson. (No. 2741.) Pp. 44+4 plates. (Washington, D.C.: Government Printing Office.)

United States Department of Agriculture. Technical Bulletin No. 95: The Meal Worms. By R. T. Cotton; with Technical Descriptions of the Mature Larvae, by R. A. St. George. Pp. 38. (Washington, D.C.: Government Printing Office.) 10 cents.

CATALOGUES.

Catalogue of Books on Mathematics, Physics, Astronomy, History and Method of Science. Pp. 28. (London: H. K. Lewis and Co., Ltd.)

Catalogue of Books on Botany, Zoology, Agriculture and Geology. Pp. 44. (London: H. K. Lewis and Co., Ltd.)

New and Recent Publications. Pp. 8. (London: Williams and Norgate, Ltd.)

Diary of Societies.

FRIDAY, JULY 5.

INSTITUTION OF CIVIL ENGINEERS (Birmingham and District Association), at 8.30 A.M.—Visit to Liverpool to see the Work in connexion with the Mersey Tunnel.

OVERHEAD LINES ASSOCIATION, at 12.15 P.M.—Visit to the Mid-Cheshire Electricity Supply Company.

GEOLOGISTS' ASSOCIATION (in Architectural Theatre, University College, Gower Street), at 7.30.—Christopher T. A. Gaster: Chalk Zones in the Neighbourhood of Shoreham, Brighton, and Newhaven, Sussex.—H. G. Smith: Some Features of Lamprophyres, near Sedbergh, Yorkshire.

SATURDAY, JULY 6.

PHYSICAL SOCIETY (at the University, Birmingham), at 3 P.M.—S. W. J. Smith and A. A. Dee: The Magnetic Analysis of Steels.—T. L. Ibbs and K. E. Grew: Thermal Diffusion at Low Temperatures.—G. Barlow and H. B. Keene: The Damping of Vibrations in Steel Tuning Forks and its Variation with Temperature.—J. Young: The Crystal Structure of Some Carbohydrates.—M. C. Johnson: Note on the Origin of Certain Interatomic Forces.

PHYSIOLOGICAL SOCIETY (in Physiology Laboratory, Oxford), at 3.30.—H. V. Horton: The Reversible Loss of Excitability in Isolated Amphibian Voluntary Muscle.—C. W. Carter and A. N. Drury: Heart Block in Rice-fed Pigeons.—Samson Wright and H. A. Bulman: Physiological Action of X-Rays.—G. P. Crowden and E. Ogden: The Effect of Adrenaline on the Non-protein Nitrogen in the Blood of Decerebrate Cats.—G. Ekehorn: Some Observations on the Concentration of Glomerular Fluid.—Prof. H. E. Roaf: Visual Acuity with Light of Short-wave Lengths.—Prof. R. A. Peters: Observations upon the Oxygen Consumption of *Colpidium colpodi*.—Demonstrations: —S. Cooper and J. C. Eccles: Isometrically Recorded Motor Responses in a Mammalian Preparation.—H. M. Carleton: Some Recent Methods in General Histology (Microscopes).—Dr. J. F. Fulton and E. G. T. Liddell: Chronic Decerebellate Animals.—J. C. Eccles and Sir C. S. Sherrington: Reflex Summation.—J. C. Eccles: Fluid Electrodes suitable for the Mammalian Preparation.—T. Lewis: Standard Colours for estimating Cyanosis in Skin.

MONDAY, JULY 8.

SOCIETY OF CHEMICAL INDUSTRY (Manchester Section) (Annual General Meeting) (at Municipal College of Technology, Manchester) (and on July 9 to 13).

TUESDAY, JULY 9.

SOCIETY OF CHEMICAL INDUSTRY (at Manchester), at 10.15 A.M.—Annual General Meeting.—Dr. A. D. Little: Science and Labour.

SOCIETY FOR THE STUDY OF INEBRIETY (at 11 Chandos Street, W.), at 4.—W. McAdam Eccles: Some Gaps in the Study of Inebriety (Presidential Address).—Sir William Willcox and others: Discussion on The Toxic Effects of Methylated Spirits and Impure Forms of Alcohol.

WEDNESDAY, JULY 10.

SOCIETY OF CHEMICAL INDUSTRY (at Manchester), at 10 A.M.—Annual Meeting.—Prof. T. H. Pear: The Human Factor in Industry.—Dr. A. D. Little: Process Development.

INSTITUTION OF MINING ENGINEERS (at University College, Nottingham), at 11 A.M.—General Meeting.—Dr. W. Hancock, A. G. R. Whitehouse, and Dr. J. S. Haldane: The Salts lost by Sweating owing to High Air-temperatures (Sixteenth Report to the Committee on The Control of Atmospheric Conditions in Hot and Deep Mines).—Dr. J. S. Haldane: Work of the Committee of the Institution of Mining Engineers on The Control of Atmospheric Conditions in Hot and Deep Mines.—The following papers will be submitted for further discussion:—W. S. Cooke and I. C. F. Statham: The Flow of Air at Bends and in Straight Airways (Sixth Report of the Midland Institute Committee on the Ventilation of Mines).—Dr. T. David Jones: Spontaneous Combustion in North Staffordshire. Part II. A Record of Analyses of Air-samples taken during the Combating of a Fire.—Dr. T. F. Wall: Electro-magnetic Testing of Wire Ropes.—2.15.—The General Meeting will be resumed.—3.30.—The General Meeting will be closed.

TUESDAY, JULY 16.

SOCIETY OF CHEMICAL INDUSTRY (South Wales Section).—Visit to the Works of Messrs. J. S. Fry and Sons, Ltd., at Somerdale, near Bristol.

PUBLIC LECTURE.

TUESDAY, JULY 16.

UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL, at 5.—Sir Thomas Lewis: Observations Relating to the Mechanism of Raynaud's Disease (Victor Horsley Memorial Lecture).

CONFERENCES.

JULY 10 TO 12.

ELECTRICAL ASSOCIATION FOR WOMEN (at North-East Coast Exhibition, Newcastle-upon-Tyne).—Fourth Annual Conference.

JULY 12 TO 14.

MIND ASSOCIATION (Annual Meeting) (jointly with Aristotelian Society) (at University College, Nottingham).

Friday, July 12, at 8 P.M.—Prof. F. Granger: Probability and Paradox.

Saturday, July 13, at 10 A.M.—Prof. G. E. Moore and H. W. B. Joseph: Indirect Knowledge.

At 2.—Prof. J. Laird, C. E. M. Joad, and Miss L. S. Stebbing: The Present Position of Realism.

At 8 P.M.—J. D. Mabbott, H. H. Price, and G. Ryle: Negation.

Sunday, July 14, at 2.—Prof. G. Dawes Hicks, Prof. B. Edgell, and Prof. G. C. Field: Immediate Experience.

At 8 P.M.—Address.

JULY 13 TO 20.

ROYAL SANITARY INSTITUTE (at Sheffield).

In Sections devoted to Preventive Medicine, Architecture and Engineering, Maternity and Child Welfare (including School Hygiene), Hygiene of Food, Hygiene in Industry, Veterinary Hygiene, Representatives of Sanitary Authorities, National Health Insurance Services, Medical Officers of Health, Engineers and Surveyors, Sanitary Inspectors, Health Visitors (including Personal and Domestic Hygiene).

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