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Co-operation in Research throughout the British Empire.

ONE of the most useful discussions at the Congress of the Universities of the Empire held at Cambridge last year, the official Report[1] of which has been published, was on "Co-operation in Research throughout the Empire." The subject is so attractive and appropriate to the times in which we are living that one may be pardoned for overlooking how modern is the idea of co-operation in the field of scientific research. Diogenes living in his tub, and asking nothing of the kings and satraps of the world except to get out of the sunlight, represents the traditional conception of a philosopher. Newman, in the preface to his "Discourses on the Scope and Nature of University Education," insists on the necessary solitude of the scientific investigator. "The common sense of mankind," he says, "has associated the search after truth with seclusion and quiet." The greatest thinkers are men of absent minds and idiosyncratic habits. Pythagoras lived for a time in a cave; Thales refused the invitation of princes. Friar Bacon lived in his tower upon the Isis; Newton in an intense severity of meditation which almost shook his reason. Who among his contemporaries, we may well ask, could claim to share the labours

> "Of Newton, with his prism and silent face,
> The marble index of a mind for ever
> Voyaging through strange seas of Thought, alone"?

In Newman's opinion, to discover and to teach are distinct gifts, not commonly found in the same person. This idea may explain the tentative way in which the teaching universities of Great Britain took up the work of scientific research. In Victorian Oxford, the Rev. C. L. Dodgson—better known as Lewis Carroll, the author of "Alice in Wonderland"—ridiculed the claims of science to a place in university curricula. Science, he says, sat weeping at the gates. Oxford admitted her and housed her royally, adorning her palace with retorts and reagents and making it a charnel-house of bones. When the students sniffed at the sulphuretted hydrogen and turned away, science said: "Give me no more youths to teach; and pay me handsomely and let me think." Making allowance for the whimsicality of the author of "Alice in Wonderland," we may acknowledge a modicum of truth in this description of the origin

[1] Third Congress of the Universities of the Empire, 1926: Report of Proceedings. Edited by Alex Hill. Royal 8vo. Pp. xxviii+270. (London: G. Bell and Sons, Ltd., 1926.) 21s. net.

of scientific research at Oxford. The sister university organised its research work more deliberately; but only in recent years has scientific research received full recognition in our ancient universities.

As to the Government, nothing less than the greatest war in history was necessary to bring about active participation in this work. The bombs from enemy airships were actually dropping on London when the organisation of the Department of Scientific and Industrial Research was in progress. The Dominions — Australia, Canada, South Africa, and New Zealand—and India followed the example of the mother country. Not yet, however, as is shown by the discussion at the Universities Congress, have all the problems of co-operation in the field of scientific research found their solutions.

Sir Thomas Holland in his opening address to the Congress gave a résumé of the scientific activities within the Empire stimulated or organised during the War. Established streams of international exchange were altered by the War. For example, the output of wolfram in south Burma, the principal source of that mineral, was before the War sent to Germany, and the tungsten extracted therefrom, an important constituent of tool-steel, was rationed to English firms. Some precious months of intensive research under the compelling impetus of war were necessary to elucidate a satisfactory process of manufacture; but that, Sir Thomas Holland said, was only "one of the many shocks which followed the winter operations of 1914–15." In the light of such an experience, the need for "official organizations for correlation and control" could scarcely be disputed. Their relations to British universities and industries are still in process of adjustment. Sir Thomas Holland was not disposed to accept Newman's dictum regarding the independence of teaching and research. The highest teaching, he said, loses its vitality if unconnected with research.

Conversely, the question arises: To what extent and in what directions does research suffer if divorced from teaching? Sir Thomas did not suggest that there was any lack of co-operation between the Department of Scientific and Industrial Research and the universities, for the Department had shown a willingness to hand over problems to research workers in university laboratories and also to assist new researches proposed by university professors. But the establishment, at home and in the Dominions, of special research institutes, wholly divorced from teaching, was a new development. Certain forms of research must be conducted on a scale beyond the capacity of the ordinary university or college. Research workers always have more ideas than they can readily develop and complete in practice, and there is a greater tendency to reserve a 'claim' in a general institute, the governing body of which may not be composed of critical specialists. This danger, however, is not apparent in Great Britain so far.

Sir John Farmer addressed himself to a problem of great Imperial interest—the work of the scientific officers attached to the agricultural departments in the Colonies and of the officers of the commercial agricultural enterprises which are growing up, especially in the tropics. These officers do their work in a solitude due to physical reasons, and Sir John Farmer's appeal to the home universities to assist them by offering a welcome to the university laboratories during their visits to the mother country should meet with an enthusiastic response. For, as he said, no one has a better right to this hospitality than the man who has been coping with problems under conditions of difficulty which would astonish those who have been accustomed to the luxurious resources of some of the modern temples of science.

A good example of the importance of agricultural problems of the tropics was given by Sir Arthur Shipley. Last year we imported 60,000,000 bunches of bananas, each containing about 80 bananas, and thus the inhabitants of the British Isles consume about 100 bananas per head a year. But many of the plantations are derelict owing to the banana disease, and any one who could find a cure for the fungus which destroys the banana would make a fortune. It is to be hoped that the prognostication will be confirmed, though there are instances, *e.g.* the discoveries relating to the transmission of malaria, which would discourage over-confidence of financial reward. However, the colonial scientific research service has many attractions for the enthusiastic worker, as Sir John Farmer insists, and his appeal for "the fertilising effects of intercourse with others who are pursuing similar or analogous paths of scientific work" refers to a psychological aspect of the question of co-operation in research the importance of which it would be difficult to overstress. As a good example of co-operative research, he instanced the work of the Food Investigation Board, under the able direction of Sir William Hardy. Scientifically, the work is mainly rooted in Cambridge, with a smaller root system in London. The essence of its

success was to be found, he suggested, in the completeness of the chain of co-operation.

Dr. Andrew Balfour, Director of the London School of Hygiene and Tropical Medicine, also discussed the Imperial aspects of the question, emphasising the waste of time, money, and energy, "owing to the fact that in the great and important domain of tropical medicine men are, to a large extent, working in watertight compartments." Thanks to the Colonial Office, things are improving, and he commended also the work accomplished in India by the Scientific Advisory Board.

The important part which India is destined to play in the promotion of scientific research was well brought out by several Indian speakers. As Sir Jagadis Bose said, there has never been in India any real conflict between religion and knowledge. Those who pursued knowledge regarded themselves as dedicated to a sort of religious life. "In India," he said, "we combine all these qualities—inner vision, power of invention, control of our hands." India is determined to be the brightest jewel in the Imperial crown by reason of its contribution to the spiritual wealth of the British Empire. If the spirit of co-operation in research can be developed, the Empire will become, as Prof. Radhakrishnan said, "a spiritual whole" and thus serve the interests of humanity.

T. LL. H.

The Work of the British Geophysical Observatories.

Air Ministry: Meteorological Office. The Observatories' Year Book, 1923: comprising the Results obtained from Autographic Records and Eye Observations at Lerwick, Aberdeen, Eskdalemuir, Cahirciveen (Valencia Observatory), Richmond (Kew Observatory), and Benson. Published by Authority of the Meteorological Committee. (M.O. 279.) Pp. 371 + 12 plates. (London: H.M. Stationery Office, 1926.) 63*s.* net.

ONE of the important functions of the Meteorological Office is the maintenance and administration of the observatories at Lerwick, Aberdeen, Eskdalemuir, Valencia, Benson, and Kew, at which a considerable variety of geophysical work is done. The volume under review is the record of that work for 1923 and forms the second of a series which replaces certain sections of the well-known "British Meteorological and Magnetic Year Book." The evident purpose of the new series is the collection in compact form of all the work done at each observatory.

The six institutions named differ in their aims and, apparently, in the power of their equipment to deal with the wide range now covered by geophysical investigations. Lerwick Observatory, opened in 1921, is as yet confined to terrestrial magnetism, and even for this subject the staff and equipment have been so restricted that the enormously important work waiting to be done there cannot be undertaken. Aberdeen is concerned solely with meteorology and has earned a high reputation in the study of cloud forms. Eskdalemuir is primarily a magnetic observatory, but includes atmospheric electricity, seismology (since removed to Kew), and meteorology. Kew, after a long and honoured record of research in terrestrial magnetism, is changing in character and its present functions appear to be somewhat indefinite. Benson has been occupied with work on the upper air, but has been closed on this work being transferred to Kew. Valencia is a 'first order' meteorological station and includes in its programme a weekly observation of the magnetic elements.

Such diversity of aim is explained by the historical development of each observatory, and chiefly by the circumstance that, in their origins, they are not all creations of the Meteorological Office. From one point of view it may be regarded as an element of strength rather than of weakness. The important matters are, first, that where their aims are common their results should be comparable; and, secondly, that in each subject of inquiry or record, its distribution among the observatories should provide an adequate representation of the area with which they are supposed to deal.

With regard to the first of these, the volume now under review gives ample evidence of the care taken by the Meteorological Office to bring its records to a common measure. Take, for example, the hourly readings of atmospheric pressure at Aberdeen, Eskdalemuir, Valencia, and Kew. In all respects, except that of height above sea-level, they are entirely comparable, and the inquirer is not maddened by doubts as to the exact position of the recording instrument, the times and methods of observation, the units employed, and the corrections applied. Nor is he referred for information on such matters to some former publication to which he may not have immediate access. The same may be said of records of temperature, humidity, sunshine, and rainfall at these four stations. Although it would be absurd to become dithyrambic over the thousands of columns of figures in these tables, they recall Gibbon's praise of the learned Lutheran's

encyclopædic treatise, for they are "full, rational, and correct." Closer scrutiny, it is true, will reveal minute differences in observatory practice in compiling some of the other tables, but, except in one, they are not serious. Aberdeen seems to enjoy a monopoly in atmospheric optical phenomena. Further, the occurrence of such phenomena is entered sometimes under the appropriate hour, sometimes in the "Remarks" column, and sometimes in both. Unusual visibility is frequently recorded by the Beaufort letter, occasionally by the Beaufort symbol, and may appear indifferently under the hour or in the "Remarks." The exception referred to is that of wind measurement, for there is still a distressing variety in the instrumental means employed for the purpose at the different observatories. But taking them as a whole, there can be nothing but praise for the laborious care which has been bestowed on the preparation of these fundamental tables.

The second point referred to above may be fitly exemplified by considering the arrangements for continuous registration of wind over the British area. For a comprehensive study of this subject the materials are, as yet, far from complete. In addition to the observatories there are about thirty other anemometric stations within the area. But their distribution cannot be regarded as satisfactory. About half of them are to be found along or close to the English Channel coast, and it is abundantly evident that their increase in recent years has been rather in the interests of the applications of meteorology to aviation, than in those of the pure science itself. Here, as elsewhere, it must be insisted upon that in the last analysis these latter interests must be predominant. Again, considering the importance to the study of British weather of the frequent depressions in the Icelandic region, one would expect that the north-west coast of Scotland might be represented in the distribution. But until the establishment last year of a new anemometric station on the island of Tiree, this area was a blank. Information is still required from such places as St. Kilda, North Uist, and from Lerwick Observatory, where wind blows with an intensity unknown to the Sassenach. The wind data from the observatories published in this volume are as complete as can be reasonably expected and are admirably arranged. The annual distribution of frequency might be supplemented by the figures for previous years, for these are not in all cases readily accessible. Prof. Becker has published results which would indicate a very marked decrease in the frequency of high winds over the Glasgow district during the last half-century, and it is more than a merely superficial impression which inclines one to the belief that there has been a parallel decrease in the frequency of gales in the North Sea. It would be of interest to have these conclusions examined.

It is not the object of the "Year Book" to give any discussion of general results deducible from the meteorological data. A partial exception to this general rule is to be found in the harmonic analysis of diurnal variations of atmospheric pressure at Eskdalemuir, Valencia, and Kew, and of temperature at the two latter stations. Those for Aberdeen are not given, for some reason unexplained. This extension of the tabulated data is most welcome. But it is hoped that it will not be taken as an indication of ingratitude if a request be made for still more; that is, that the hitherto unpublished series 1913–21 be similarly analysed and issued. The subject of the diurnal variation of pressure—to which the present Director of the Meteorological Office has already made a notable contribution—is by no means exhausted, but its advance in some directions is largely impeded by the lack of trustworthy data. It may also be suggested that the value of the "Year Book" would be considerably enhanced if similar records were obtainable from Lerwick Observatory, almost the only station in the northern hemisphere providing an exposure free from the influence of large land areas, which have such marked effects on the different terms of the harmonic expansion. As Sir Napier Shaw once remarked on a parallel case, it is "somewhat depressing that the world should be content to go on without the knowledge which is needed for calculations such as this, and which is within the reach of effort." It is well known that the solar part of the diurnal pressure inequality is affected by some of the various factors which make up the meteorological character of the day, and among these, principally, the occurrence of deep depressions, with the consequent uncertainty as to the distribution of non-cyclic change. For the investigation of such effects the new arrangement of the "Year Book" is especially well adapted, since nearly all the information required for any classification of days is given in the volume.

The magnetic data published in the "Year Book" are chiefly those from Eskdalemuir, and they are given with a completeness which leaves little scope for criticism. Full details of the bi-weekly absolute determinations of D, H, and I are given, together with the base-line values, both deduced and adopted, of the N, W, and V magnetographs. But

there is, as yet, no indication of the use of modern electromagnetic methods for these fundamental determinations. The tabular matter includes hourly values of the three geographical components; hourly means for each month, and daily means for each day; maximum and minimum for each day, with the time of occurrence; absolute daily range, and the magnetic 'character' of each day. The diurnal inequalities are given very fully for 'all' days, quiet days, and disturbed days, and they are further expressed in terms of their harmonic components. The series of notes on the magnetograms of the year are of interest, for they provide abundant matter for speculation and study. What makes these notes of value is that there appears to be a better prospect of elucidating terrestrial magnetic disturbance by the study of the same disturbance in the records of several stations, than by lumping together all disturbances at one station. For example, there is sound reason for the full investigation of the diurnal variation on the same magnetically quiet days at all stations. But similar inquiry on highly disturbed days introduces elements of great uncertainty, chiefly dependent on the selection of days regarded as disturbed, on the hour of day at which a disturbance begins, and on the fact that disturbances are not all of one type. This is borne out by the vector diagrams shown in the "Year Books" of 1922 and 1923. For quiet days there is practical constancy in type for the respective seasons, while for disturbed days there is marked variation in type. But the more intensive study of the details of each world-wide magnetic storm involves a degree of international co-operation which is, as yet, far from realisation.

The magnetic results from the new observatory at Lerwick appear for the first time in this issue of the "Year Book." Until the instruments have settled down—there was heavy 'drift' on the *H* magnetograms—the published data are confined to diurnal inequalities of the horizontal components, daily range in declination, and to general annual results. These show that magnetic disturbance at Lerwick is on a much larger scale than at Eskdalemuir, itself a fairly disturbed station. For example, the daily range in declination at Lerwick on Sept. 27, 1923, exceeded $2\frac{1}{2}°$—very much greater than it would have been at Eskdalemuir. Dr. Chree contributes an interesting discussion of the chief results. The volume also includes a summary of the auroral log of the observatory, but this is practically confined to a list of the fifteen dates on which auroræ were visible. The powers that are swayed by the "interests of brevity," to which apologetic reference is made, have evidently been at work. Nothing is said as to any extension of the auroral work, one of the chief objects for which this observatory was established.

Eskdalemuir Observatory contributes its earthquake and microseismic records, and these are given in full. In connexion with the latter, there are interesting notes intended as comment on the theory that microseismic amplitude and the travel of cyclonic depressions over the European area are correlative. The agreement with the Strasbourg microseismic record is at times very striking. Among minor, but not the less important and interesting, subjects there may be noticed the atmospheric potential gradient measurements at Eskdalemuir and Kew; the record of atmospheric pollution at Kew; and the soundings by registering balloons sent up from Benson.

The "Year Book" is the record of an immense amount of laborious work in measurement, tabulation, and computation. Much of it, necessarily, is of the nature of that routine which tends to diminish zeal, but the work has been carried through on a level, in respect of quality, which commands nothing but praise. The Meteorological Office has many functions to fulfil. Some of these —forecasting weather, for example—are of general importance; others—among which may be classed the provision of information for aviators—are significant of administrative accident rather than of importance in themselves. But it has also the paramount obligation of providing the material for the advancement of that science upon which its own activities are based. The present substantial addition to the published data of geophysics is a welcome evidence that this responsibility is being discharged, and on its issue the Meteorological Office must be congratulated.

A. CRICHTON MITCHELL.

Geology of South Africa.

The Geology of South Africa. By Dr. Alex. L. Du Toit. Pp. xi + 463 + 39 plates. (Edinburgh and London: Oliver and Boyd, 1926.) 28*s*. net.

SOUTH Africa is characterised geologically by its unity in plan and its variety in structure and composition. It is of special interest to European geologists, as its Karroo formation is an important supplement to their records, as it claims to be the original home of reptiles, mammals, and man, and as it contains the most prolific of the world's goldfields and diamond mines, and the largest known supply of primary platinum ores.

Its present unity and isolation are due to Mesozoic movements that severed it from South America and Australia, which have many features in common; for the three areas shared the same early geological history, presenting, however, the differences that might be expected from such far-distant sections of the same continent.

The geology of South Africa is well adapted to individual treatment, and it has been described in an excellent series of text-books, of which that by Dr. Du Toit is the latest and most complete; it will be exceptionally useful from its concise statement of the evidence, its references to the literature, its beautiful map, clear plates and diagrams, and the author's sound and cautious judgment. His caution is shown in dealing with the oldest South African rocks. He is confident that they are pre-Devonian, but how far they are Palæozoic or pre-Palæozoic he leaves open. The Waterberg Sandstone he treats as early Palæozoic, though no fossils have been found in it; the reviewer in 1915, when describing its north-western extension in Angola, adopted its pre-Palæozoic age somewhat tentatively, but the later evidence and drift of opinion are in favour of that conclusion.

The view that the Waterberg Sandstone is the inland equivalent of the Devonian Table Mountain Sandstone, and that the underlying dolomites are Ordovician, has had a strong appeal to South African geologists; and it was strengthened by the claim that Orthoceras had been found in the Otavi Dolomite; but as there is no mention of that fossil, it may be assumed that the author dismisses it as a concretion. The most important formation amongst the earlier rocks is the Banket of the Transvaal goldfield. The author discusses whether its gold was alluvial or due to infiltration, and says that the criteria are indecisive (p. 69); but he adds that "the placer theory appears by far the most likely," and in his final chapter he gives a graphic summary of the geological history of the field, which follows exactly the views urged by the reviewer in 1907, including the formation of the pyrites from black iron sand, the shaping of the typical Banket pebbles by beach action, the alluvial origin of the gold, and its recrystallisation, and the existence of gold in washouts through the Banket and of pebbles of that rock in the Ventersdorp conglomerates. The facts show that the gold is earlier than the Ventersdorp igneous activity to which it is attributed by the advocates of infiltration. The main difference is that Dr. Du Toit describes the pebbles as muffin-shaped instead of bun-shaped. Dr. Du Toit rejects the view of Dr. Mellor that the Banket was formed by a sudden deltaic flood, and adopts the earlier view that it was formed by long-continued surf action on a sinking shore. The Banket of Southern Rhodesia, which was formerly claimed by most South African geologists as a crush conglomerate, the author accepts as sedimentary.

One especially valuable section of the work is the up-to-date account of the Karroo System, and of its reptiles and correlation. It includes an admirable description of the Upper Carboniferous glacial deposits and glaciated surfaces. The author represents the glaciation as radiating from four centres, of which one lay to the east of the present coast. He accepts the age as Upper Carboniferous, and deplores the use in Australia of "that unfortunately misleading term Permo-Carboniferous" . . . "an illogical practice that has immensely obscured the true issue." Fortunately the Australian Permo-Carboniferous is now restricted within comparatively narrow limits. The famous Dwyka glaciation was not the first in South Africa, as the author describes the evidence for that in the Transvaal Period from Griqualand and Namaqualand. The coal of the Karroo does not rest on underclay, and the roots of the fossil forest described spread over the top of the coal as if the trees had spread over an accumulation of vegetable matter on the emergence of the land. There is a valuable synopsis of the Cretaceous fossils of South Africa and description of the recent efflorescent rocks, calcareous, lateritic, and siliceous. Dr. Du Toit has given special attention to water supply, and his valuable chapter on that subject describes the interesting tidal wells at Cradock in the east-central part of Cape Colony.

The economic geology of South Africa is especially instructive. The diamonds are widely scattered, and in considering their formation the author is not unduly influenced by the Kimberley pipe. He points out that nine-tenths of the kimberlite occurrences are barren of diamonds, and it appears that at least most of those that yield diamonds contain tourmaline in addition to the mineral species proper in an ultra-basic rock. He accepts Dr. Wagner's conclusion as to the diamonds of south-west Africa, as Kaiser's monograph on that field appeared too late for consideration of its evidence for a different explanation. The most important recent contribution of South Africa to the mineral wealth of the world is that of platinum; the author gives an account of the information available as to its distribution up to the date of the completion of his manuscript. He accepts the

view that some of the platinum is a direct segregation in ultra-basic rock; but he recognises the bulk of the ore of commercial importance as a metasomatic formation, while the platinum in the quartz veins is also due to some hydrothermal agency. The Transvaal has not yet had any important output of platinum; but the prospecting work encourages the hope that the South African yield will materially reduce the price of that useful metal. J. W. GREGORY.

Plants and People of South-west China.

Naturbilder aus Südwest-China: Erlebnisse und Eindrücke eines österreichischen Forschers während des Weltkrieges. Von Dr. Heinrich Handel-Mazzetti. Pp. xiv + 380 + 77 Tafeln. (Wien und Leipzig: Österreichischer Bundesverlag für Unterricht, Wissenschaft und Kunst, 1927.) 24 gold marks.

UNDER the auspices of the Academy of Sciences, Vienna, Dr. Handel-Mazzetti, the well-known Austrian botanist, made extensive explorations in south-west China during the years 1914–1918; and this handsome volume is a popular account of the scientific results of these travels. The book is remarkable for the wealth and beauty of the illustrations, which are reproductions of photographs, a considerable proportion being autochromes, that depict the scenery and vegetation in their natural colours. It is the first time that we have had an opportunity of seeing pictures of the wild habitats of many beautiful plants that have been recently introduced into our gardens from China. The book makes, accordingly, a strong appeal to horticulturists; and we hope that a translation into English will soon be published.

Compelled by the outbreak of the War to remain in China for nearly five years, Dr. Handel-Mazzetti explored with great zeal one of the richest floral regions in the world. During the first three years, 1914–1916, he travelled to and fro across the high plateau of western Yunnan, and made numerous ascents of the lofty peaks and ranges on the boundary adjoining Tibet. He crossed and recrossed the deep gorges of the Yangtze, Mekong, Salwen, and Irrawaddy, where these four great rivers, flowing parallel in a narrow space (lat. 27°-28°), form perhaps the wildest and most romantic scenery on the face of the globe. Overcoming incredible difficulties with limited resources, he amassed a vast collection of botanical specimens, and took numerous photographs and observations illustrating the topography, geology, and ethnology of the region.

During 1914, Dr. Handel-Mazzetti went northward into the province of Szechwan, and penetrated into Ta Liang Shan, the secluded kingdom of the Independent or Black Lolos, an interesting aboriginal race, to whom he devotes a chapter of description and several pictures. Scattered through the book are notes and illustrations of many other peculiar peoples—Moso, Nahsi, Lissu, Miao, and various Tibetan tribes. An attractive autochrome (Pl. 36) represents the Moso village of Kua-pi, the seat of an hereditary chief.

Special attention is paid to plant ecology, all the different formations being described and illustrated. We may quote as an example Pl. 39, which represents in colour a mountain meadow at 11,000 feet altitude, gay with flowers of Primula, Pedicularis, Trollius, and Anemone. The most characteristic genus of woody plants is Rhododendron, of which more than 300 species have been distinguished in China. Twenty of these are shown in their natural surroundings.

Of herbaceous plants, Primula is perhaps the genus richest in species; and Pl. 110 shows one of the most beautiful of these, *P. calliantha*, growing at 14,000 feet elevation. Of the orchids, *Cypripedilum ebracteatum*, depicted in colour in Pl. 76, is most remarkable. Other showy flowering plants, figured in their native habitat, are the giant gentian, *G. stylophora*, shown in Pl. 50, and *Lilium giganteum*, Pl. 104, which are common in open glades of the mountain forests.

Conifers constitute the mass of the forests at high altitudes in western China, and are rich in indigenous species. Dr. Handel-Mazzetti's discovery of the rare Formosan genus, Taiwania, in the gorges of the Salwen River, is a notable achievement. He also found the so-called 'arbor-vitæ,' *Thuya orientalis*, forming woods in the valley of the Mekong. This tree, commonly planted around temples and in cemeteries throughout China, has been supposed until now to be a native of the Peking mountains; but its occurrence in the wild state in southern China suggests that it has been carried from there northwards and distributed by Buddhist priests.

In 1917, Dr. Handel-Mazzetti left Yunnan and travelled eastward across the province of Kweichou into southern Hunan, ultimately reaching Changsha, the capital of the latter province. Here he remained for some time exploring the mountains to the westward, but under great difficulties, as the Chinese were at the moment in a state of civil war.

The account of his explorations in Kweichou and Hunan, where he broke new ground, are of great interest; and the illustrations show wonderful scenery and rich vegetation. He left Changsha for Shanghai on Feb. 26, 1918, and this date marks the end of a succession of perilous journeys in the cause of science. A. HENRY.

Our Bookshelf.

Classified Problems in Chemistry. By D. B. Briggs. Pp. viii + 152. (London: Sidgwick and Jackson, Ltd., 1926.) 3*s*. 6*d*.

THE author has made a praiseworthy attempt to provide a number of numerical problems in chemistry, arranged in methodical order for use in schools. Many of the examples are taken from examination papers of British universities, the Civil Service, and other authorities, quite a number being culled from Cambridge Tripos papers. The arrangement of chapters and sections is excellent, but the explanatory notes might have been expanded, since they will scarcely suffice for the solution of all the problems. Instead of four pages of notes on the use of logarithms, a section might have been included dealing with limits of error and accuracy, a stumbling-block to many beginners. The method of calculation on p. 24 is admirable, but in dealing with volumetric analysis it would have been better to explain the use of equivalent weights, the dependence of equivalents on the reaction studied, and the effect of any change in the equivalent weight of a compound. Experience has shown that many pupils on leaving school have failed to grasp the simplicity of this method of calculation, and until it is generally adopted, volumetric analysis will appear to be more difficult than it is.

A number of inaccuracies have been detected; for example, in question 10, p. 31, the molecular weight of ammonia can not be deduced from the data, nor can the atomic weight of the metal be found accurately in question 12, p. 47. The weight of potassium chlorate in question 22, p. 78, is not 1·08 grams, and the percentage of silver in question 44 on p. 134 is incorrect. Teachers will nevertheless find the book most useful.

Organic Syntheses: an Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals. Editorial Board: Henry Gilman, Editor-in-Chief, Roger Adams, H. T. Clarke, J. B. Conant, C. S. Marvel, Frank C. Whitmore. Vol. 6. Pp. vii + 120. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1926.) 7*s*. 6*d*. net.

THE preceding volumes of this series have been reviewed in these columns and are well known to most chemists. The present volume is in every respect similar. Some of the syntheses described are likely to be of use to research workers in the preparation of their starting materials, such as the syntheses of acrolein, benzil, octanol, and hexanol, but others are more of the nature of students' preparations. The reviewer himself has tested the synthesis of acrolein given, and found that the notes simplify the process considerably and that the yields quoted can easily be reproduced. The volume also contains the recent references in the current literature relating to syntheses published in the previous volumes, and the policy is adhered to of repeating syntheses when improved methods have been afterwards described, *e.g.* benzil. While these volumes serve a very good purpose, it is a great pity that the price charged should be so large. As it would ultimately be best to have the volumes bound together, it would be a good plan if a cheaper edition were published with less elaborate bindings.

A Manual of Navaho Grammar. Arranged by Fr. Berard Haile. Pp. xi + 324. (St. Michaels, Arizona: Franciscan Fathers, 1926.) 6 dollars.

THIS study of Navaho grammar, which it may be said is a very thorough piece of work, might well be recommended not only to the student of the linguistics of the North American Indian, but also to those who are interested specifically in his psychology. The chief grammatical devices for the expression of ideas in Navaho are the noun and the verb. Of these the verb is of special importance in this connexion, as it most markedly brings out the distinctive point of view of the Indian mind, which emphasises minute detail in relation to perceptible things. These are described with infantile accuracy. The verb structure therefore gives expression to the attention which the Indian pays to size, shape, form, directional position, and like qualities of the subject. A great deal of work is thus thrown on the verb by means of adverbial prefixes and suffices. In Father Haile's arrangement of the grammar, careful attention has been given to this aspect as well as to the verb stem. Notwithstanding a considerable amount of research along this line, the author acknowledges that much still has to be done.

Exploring England: an Introduction to Nature-craft. By Charles S. Bayne. Pp. 216 + 16 plates. (London: Jarrolds Publishers London, Ltd., n.d.) 7*s*. 6*d*. net.

THE 'exploring' of this work is the exploration of the naturalist in the familiar places of the country-side, and 'England' need scarcely have limited the study, for with few exceptions the creatures described occur throughout the British Isles, while at least one of them, the crested tit, is confined to Scotland, and others, like the dotterel and the grey lag-goose, are mentioned only in connexion with their nesting there. In turn the author visits the hedgerows, the woods, the streams and marshes, the coast, and so on, and describes the plants and animals which are likely to be found in each type of area. There are many shrewd observations on the habits of wild creatures, but the descriptions and illustrations are insufficient in many cases to guide the novice to the identity of his quarry, and that is a first essential in nature-craft.

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.*]

Hardness of Alloys.

IN continuation of my note on the hardness of metals in NATURE of Feb. 19, I now subjoin diagrams showing the variation of hardness which occur in certain alloys of copper with the percentage of the alloying metal (Fig. 1).

The alloys were prepared by melting, in a quartz test-tube and in an atmosphere of hydrogen or coal gas, the proper proportions of the constituent. When melted these were stirred by shaking the tube, which was then allowed to cool. This left the alloy in the form of a 'button,' from which the test-pieces were cut. No hammering or any kind of work other than that required to file or grind them to a conical shape was used in their preparation; all the hardnesses indicated in the diagrams therefore refer to cast metal.

In these diagrams the ordinates give the hardness in tons per square inch, the abscissæ being the volume percentage of the alloying metal, that is, so much per cent. of the volume consists of the alloying metal and the rest of copper.

In every case, except that of bismuth, there is a certain amount of hardening as the percentage of alloying metal increases to something like 30 per cent., and in general the alloy becomes brittle near the point of maximum hardness.

To determine the ordinates of the 'hardness' curves, eight alloys were prepared for each of the metals used (or ten if pure metal at each end of the percentage scale is included), and though the brittle specimens were difficult to deal with, I believe that the result gives a fair representation of the facts.

Some of the alloys, notably those containing tin and antimony, though not hard, could not be cut with a saw, the saw refusing to bite when applied with a light pressure, and splintering the metal when the pressure was increased.

It seemed worth while, therefore, to measure the coefficient of friction of the alloys under such high pressures as exist at the cutting edges of the saw teeth and at the point of the conical test-pieces.

The measures were made by the apparatus sketched in Fig. 2. A platform mounted on rollers carries a polished plate of some hard material, on which the loaded test-piece presses. A lateral force is applied to the platform by a spring balance, and the reading of this balance when the force is just sufficient to cause the hard surface to slip under the point is noted.

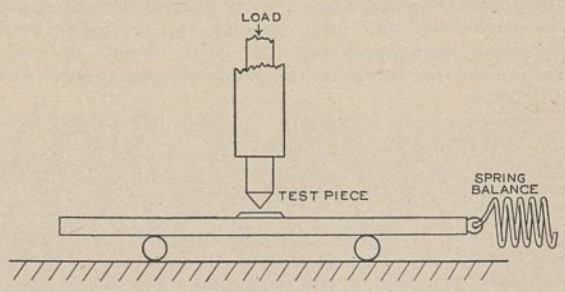

FIG. 2.

COEFFICIENTS OF FRICTION UNDER HIGH PRESSURE.

	Coefficients of Friction.	Pressure. Tons per square inch.
Steel on Glass . . . dry	0·12	111·0
,, ,, . . . in water	0·125	110·0
,, ,, . . . in oil	0·12	110·0
,, on Sapphire . . dry	0·1	117·0
,, ,, . . in water	0·101	117·0
,, ,, . . in oil	0·114	117·0
Pure Copper on Sapphire . dry	0·100	20·0
Pure Cadmium on Sapphire . dry	0·1	2·3
Pure Tin on Sapphire . . dry	0·124	0·22
Copper Alloy 20 % Zinc on Sapphire dry	0·100	32·0
,, ,, 28 % Tin on Sapphire dry	0·084	68·0
,, ,, 40 % Tin on Sapphire dry	0·085	16
,, ,, 40 % Tin on Steel dry	0·090	16
,, ,, 15 % Bismuth on Steel dry	0·092	5·8
,, ,, 15 % Bismuth on Sapphire . dry	0·092	3·7
,, ,, 20 % Antimony on Sapphire . dry	0·094	5·2

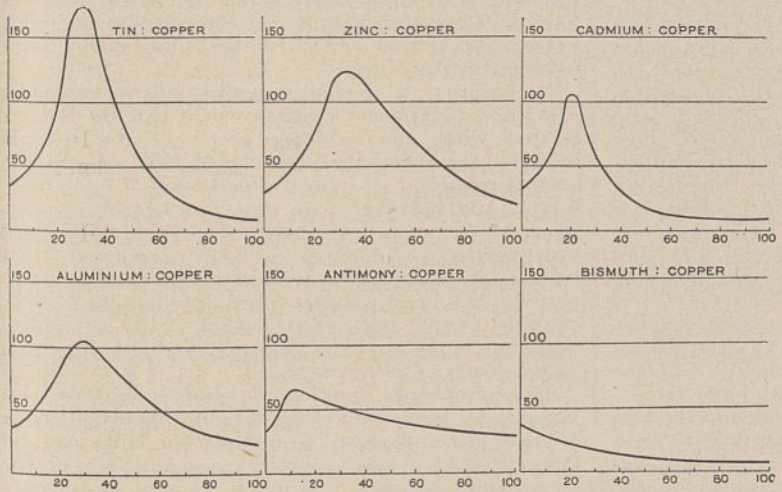

FIG. 1.—Hardness of alloys of copper. Ordinates give hardness in tons per sq. in.; abscissæ give volume percentage of alloying metal.

The Table above gives samples of the result obtained. When the plates were well polished the balance readings were very consistent, and the force required to cause 'slip' was closely proportional to the load on the test-piece.

It appears that with these high pressures, lubrication has no practical effect, the lubricant, I suppose, being completely squeezed out.

It appears also that for pressures of the order employed, the pressure itself is a matter of indifference, the important factors being the nature of the materials and the product of the area of contact and the pressure, *i.e.* the load. It would occupy too much space to give the details of these experiments, which I hope to repeat with a more convenient form of apparatus.

A. MALLOCK.

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The Theory of the Paramagnetism of Oxygen and Nitric Oxide.

THE two important paramagnetic gases are oxygen and nitric oxide, and to account numerically for their susceptibilities has long been a puzzle. The new quantum mechanics, together with recent spectroscopic data for nitric oxide, seem at last to solve the difficulties.

Sommerfeld ("Atombau," p. 641) has shown that the susceptibility of oxygen can be explained by assuming that, despite the presence of two nuclei, the magnetic behaviour of the O_2 molecule is like that of an *atom* in a ^3S state. This apparently involves the unreasonable hypothesis that the angular momentum responsible for the magnetic moment is directly quantised relative to the magnetic field rather than relative to the rest of the molecule. In S states the angular momentum, to be sure, arises entirely from internal spins, and spin axes are more loosely coupled than the orbits themselves. Even so, however, the internal forces doubtless ordinarily (except in highly excited states) predominate over the external field; for the latter can, in fact, be made as small as we please.

The solution of this dilemma is, I believe, found in a very general derivation I am publishing elsewhere (*Phys. Rev.*, May 1927) of the Langevin formula $N\mu^2/3kT$ for the susceptibility χ. This proof uses the new quantum mechanics and supposes only that the molecule have a 'permanent' moment μ, and that the separation between component energy levels of the normal state be small compared to kT. This condition is doubtless fulfilled in O_2, for frequencies of nuclear rotation are ordinarily small compared to kT/h, and the superposed precession of the spin axis is much slower in S than in P or D states because of the vanishing orbital angular momentum. If μ arises entirely from spin moment, then by the new mechanics we get $\mu^2 = 4s(s+1)M^2$, where M is the Bohr magneton $he/4\pi mc$ and $s = 1/2$ for doublet terms, $s = 1$ for triplets, etc., thus giving agreement with Sommerfeld's susceptibility formula for atomic S terms. There is now, however, nothing in the proof to prevent the spin axis being quantised either (a) relative to the axis of figure or (b) relative to the axis of temperature rotation (Hund's classification), or even from being coupled in a manner intermediate between (a) and (b).

The case of nitric oxide is particularly interesting. The spectroscopic data of Jenkins, Barton, and Mulliken (NATURE, 119, 118; 1927) and others, show that the normal state of nitric oxide is a ^2P doublet. The upper and lower components have respectively $\sigma = 3/2, 1/2$, and are separated by 122 cm^{-1}. Here σ is the angular momentum about the axis of figure, measured in multiples of the quantum unit $h/2\pi$, and equals $\sigma_k + \sigma_s$, where $\sigma_k = 1$ is the component of orbital angular momentum along this axis, and $\sigma_k = \pm\frac{1}{2}$ is the corresponding component for the spin angular momentum. Because the spins have twice the normal ratio of magnetic moment to angular momentum, the upper and lower components therefore have respectively magnetic moments $2M$ and 0 along the axis of figure. Calculations of the susceptibility for a mixture of molecules with two and zero Bohr magnetons, with relative abundance determined by the Boltzmann temperature factor, do not, however, agree with experiment. This failure is due to neglect of the component of spin magnetic moment perpendicular to the axis of figure. We may, on the other hand, disregard the perpendicular component of orbital moment, as this doubtless precesses very rapidly. If the precession frequency $\Delta\nu$ of the spin axis about the axis of figure were small compared to kT/h, we could simply take $\mu^2/M^2 = \sigma_k^2 + 4s(s+1) = 4$ in the derivation of the Langevin formula cited above. Actually $\Delta\nu$ is $122c$, and so special calculations with the new mechanics are necessary, which yield

$$\chi = \frac{4NM^2}{3kT} \cdot \frac{1 + (x-1)e^{-x}}{x(1+e^{-x})}$$

where $x = h\Delta\nu/kT$. This gives a susceptibility at room temperatures corresponding to 9·12 Weiss magnetons, which agrees excellently with Bauer and Piccard's experimental value 9·20. The hope of Jenkins, Barton, and Mulliken that their spectroscopic data would permit the quantitative calculation of susceptibility is thus fulfilled. Details of the computations will be published elsewhere.

J. H. VAN VLECK.

University of Minnesota.

Influence of Carbon Monoxide and Light on Indophenol Oxidase of Yeast Cells.

WARBURG (*Biochem. Zeitschr.* 177; 1926) has shown recently that carbon monoxide at a high partial pressure inhibits the respiration of yeast and cocci cells. He also found that a respiratory substance involved in this process has a much higher affinity for oxygen than for carbon monoxide, and that the carbon monoxide compound of this substance is dissociated by the visible rays of light.

Warburg's results as to the inhibition of respiration by carbon monoxide have been extended by Haldane (NATURE, 119, 352; 1927) to the wax-moth and cress plants.

The main object of my study was to localise the action of carbon monoxide, and to find whether the substance influenced by it has any connexion with the known respiratory substances.

Cytochrome, which is present in yeast cells, does not combine with carbon monoxide. The ordinary (unbound) hæmatin which is also present in yeast cells has, on the contrary, a much greater affinity for carbon monoxide than for oxygen, and, when reduced, it combines, even at a very low partial pressure, with carbon monoxide. Thus, none of the four different iron-porphyrin compounds of living yeast cells is responsible for the phenomenon discovered by Warburg.

In addition to hæmatin compounds, yeast cells contain a polyphenol oxidase which can be demonstrated when the reducing power of the cells is inhibited by urethane, cooling on ice, or heating yeast suspension (in phosphates at pH 7·3) to 50°-52° C., and keeping it at that temperature for an hour. 2 c.c. of a 5 per cent. suspension of baker's yeast heated to 50° C. gives a strong reaction with 0·5 c.c. of 'Nadi' mixture composed of equal parts of 0·01 M. dimethyl-para-phenylenediamine hydrochloride in 50 per cent. alcohol, 0·01 M. alpha-naphthol in 50 per cent. alcohol, and 0·1 per cent. sodium carbonate in water.

The indophenol reaction of yeast is inhibited by boiling, by potassium cyanide and by carbon monoxide. The influence of carbon monoxide can be demonstrated in the following manner: 2 c.c. of the above yeast suspension is put in each of six slightly modified Thunberg's vacuum tubes and 0·5 c.c. of 'Nadi' reagent added into the bent portion of their hollow stoppers. These tubes, standing in the same rack, are filled with various gas mixtures; they are then reversed, the yeast suspension being mixed with 'Nadi' reagent, shaken for 1-5 minutes in the dark, and examined. The following are the results of such an experiment:

Tubes.	O_2 %.	CO %.	N_2 %.	Reaction.
1	7·32	63·4	29·28	XX
2	5·22	73·9	20·8	X
3	3·6	82·0	14·4	0
4	3·4	0	96·6	XXXX
5	1·8	0	98·2	XXX
6	1·1	0	99·0	XX

Similar results are obtained with yeast in which the respiration is almost completely abolished, while the oxidase is still very active.

Daylight, or the light of a ½ watt electric lamp (50 c.p.), dissociates the carbon monoxide oxidase compound, the oxidase becoming active again. To demonstrate this, six Thunberg's tubes are prepared as in the above experiments, evacuated to about 150 mm. to 200 mm. pressure of mercury, and are filled with pure carbon monoxide. These tubes, standing in the same rack, are then reversed and their contents mixed in the dark. Of the six tubes, three are covered and kept dark, while the other three are exposed to the light by shaking the rack in front of an electric lamp. After shaking for 1-5 minutes, the three protected tubes are uncovered, and the reaction in all six tubes is compared rapidly. The result is that, while the three tubes kept in dark show only a slight blueing (X), the tubes exposed to the light show a strong blue colour of indophenol (XXXX). Control experiments with tubes filled with nitrogen instead of carbon monoxide show no difference in the rate of indophenol formation in the tubes exposed to the light or kept in the dark.

Carbon monoxide was found to inhibit in a similar manner the indophenol oxidase of mammalian muscles, and the oxidation of catechol by the aqueous extract of oatmeal flour or of dry potato oxidase preparation.

These experiments show that Warburg's respiratory ferment is a polyphenol or indophenol oxidase system, which can display its characteristic reactions even in dead cells in which the respiration is abolished. All this clearly indicates that the oxidase systems revealed by the indophenol test belong to respiratory catalysts essential for the oxygen uptake by the living yeast cell.

D. KEILIN.

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University of Cambridge.

The Industrial Revolution.

I AM curious to learn the grounds upon which Miss Buer (See NATURE, Mar. 12, p. 379) bases her belief that the rise of population in England after 1750 was due to the introduction of the practice of inoculation and a consequent decline in infant mortality.

The accepted view is, I believe, that the rise was due in the first instance to the expansion of England's colonial trade, which increased twelve-fold, according to Edmund Burke, between 1702 and 1772. The growth of the demand for English cloth led to Kay's invention of the fly-shuttle in 1733. This invention doubled the weavers' output, raised the prices of yarn, and thus gave increased employment in the spinning trade.

Newcomen's steam-engine was introduced in 1712, and thenceforward made steady progress, resulting in an increased demand for coal. The new conditions inaugurated by the growth of trade and invention reacted upon agriculture and transport, and thus paved the way for the Industrial Revolution.

It is difficult to see how medical science could affect the size of a population. Unless there is more to divide, population cannot increase. Moreover, under the conditions prevailing in the eighteenth century a high rate of infant mortality would not affect the size of the population. Natural fertility would secure a replacement of the infant population. *Primo avulso non defuit alter.*

E. WYNDHAM HULME.

Littlehampton.

I SHOULD like to reply briefly to the points raised in Mr. Wyndham Hulme's letter. In my book I have laid considerable stress on the growth of commerce and its important reaction upon agriculture and consequently upon population. My reviewer has also mentioned this, though naturally stressing other points of more immediate interest to readers of NATURE.

In regard to Newcomen's engine; its use was never widespread, and, after experiment, was frequently abandoned owing to the wasteful consumption of fuel. Water-power was always preferred when available. The growth of the coal trade before 1800 was mainly due to the increasing use of coal for domestic purposes and for brewing, brick-making, forging, smelting, etc., rather than to the demands of the steam-engine. This increasing use of coal was partly due to the growing shortage of timber and partly to the development of canals.

In regard to the statement that "Unless there is more to divide, population cannot increase," from one aspect this is a truism, but Mr. Hulme seems to imply by it that production cannot be adjusted to needs. This implication is open to question. Given a sufficiently elastic social system, a growing population will stimulate production, and it undoubtedly did so in the period in question.

Neither can I agree that a high rate of infant mortality does not affect the size of a population, because the birth-rate adjusts itself to this rate. Obviously, this argument cannot hold if the birth-rate is at the maximum which natural fertility allows. The nearer the actual birth-rate is to this maximum the smaller is the possible movement of the birth-rate in an upward direction. Personally, I believe that until recent times, when the use of contraceptives introduces a new factor, the death-rate rather than the birth-rate was the prime regulator of population. In regard to the period under review, there is no evidence of any appreciable alteration of the birth-rate, but there is overwhelming evidence of a great fall in the death-rate, mainly among infants, and this fall was concomitant with a great growth of population. The fall of the death-rate was due to a variety of causes, of which inoculation was probably one. For the grounds upon which I base my conclusions I can only refer Mr. Hulme to my book, in which they are stated in some detail.

MABEL C. BUER.

The University,
Reading.

Regularity in the Spectrum of Ionised Neon.

THE spectrum of neon has been completely analysed by Paschen, but certain lines were obtained by Liveing and Dewar in 1900, and afterwards confirmed by Merton (*Proc. Roy. Soc.*, vol. 89, p. 447), which are not included in Paschen's scheme. L. and E. Bloch and Dejardin (*J. de Phys.*, May 1926) obtained these lines by the method of electron bombardment, and found that the lines come out strongly at 49 volts. They ascribed the lines to ionised neon.

I have tried to classify these lines, and have succeeded in arranging about 140 of them in groups of

multiplets. Taking the structure diagram of neon, namely,

$$\begin{array}{cccc} K & & & \\ 2 & & & \\ & L_1 & L_2 & \\ & 2 & 5 & \\ & & M_1 \quad M_2 & M_3 \\ & & N_1 \quad N_2, & \end{array}$$

it is found that the expected terms and combinations are as follows :

$$\begin{array}{lllll} {}^5L_2 \longrightarrow {}^4L_2\,M_1 \longrightarrow {}^4L_2\,M_2 & \nearrow & {}^4L_2\,M_3 & & \\ & & {}^4F\ {}^4D\ {}^4P & & \\ & & {}^2F\ {}^2D\ {}^2P & & \\ {}^2P \qquad {}^4P\ {}^2D \qquad {}^4D\ {}^4P\ {}^4S & \searrow & {}^4L_2\,N_1 & & \\ \qquad\quad {}^2P\ {}^2S \qquad\quad {}^2D\ {}^2P\ {}^2S & & {}^4P\ {}^2D & & \\ & & {}^2P\ {}^2S & & \end{array}$$

I have obtained combinations which are combinations between ${}^4L_2M_2$ and $({}^4L_2M_3,\ {}^4L_2N_1)$-terms. Two multiplets are shown below :

	${}^4P_1$	${}^4P_2$	${}^4P_3$
${}^4P_1$	36082·3 (1)	36264·8 (3)	
${}^4P_2$	35777·6 (3)	35960·0 (2)	36182·3 (2)
${}^4P_3$		35582·9 (4)	35805·5 (4)
${}^4D_1$	32825·2 (3)	33006·0 (4)	
${}^4D_2$	32726·9 (5)	32909·5 (3)	33131·9 (3)
${}^4D_3$		32803·6 (6)	33025·7 (4)
${}^4D_4$			32944·9 (5)

A complete analysis will shortly be published.

P. K. KICHLU.

Physics Department,
University of Allahabad,
India, Mar. 3.

Herbert Spencer's Electrical Apparatus.

IT may be of interest to record the fact that the electrical apparatus formerly owned by Herbert Spencer, consisting of a cylinder machine, three Leyden jars, an insulated stand and plates, with other accessories, which include an electrical pistol, is still in existence. One of the smaller pieces of apparatus bears the name G. Adams, London, who was presumably the maker, and the whole is contained in a wooden box.

The apparatus belonged originally to Herbert Spencer's father, William George Spencer, usually known as George Spencer, who kept a school in Derby and was for many years secretary of the Derby Philosophical Society founded by Erasmus Darwin. It was his practice to show electrical experiments to his pupils and at the meetings of the Society. Herbert Spencer in his autobiography says: "My father had an electrical machine and an air-pump, and from time to time classes of his pupils came to see pneumatic and electrical phenomena. I had frequently to make preparation for the experiments and aid in the performance of them. The result was that being on many occasions witness to the facts, and hearing the explanations given, I early gained some knowledge of physics. Incidentally I was led into Chemistry. One of my duties in preparing for these lectures was that of making hydrogen to fill the electrical pistol."

The history of the apparatus is well authenticated. Herbert Spencer's mother died in 1867, and shortly afterwards he gave up the Derby house and distributed most of the contents. In the autobiography he says: "Soon after my mother's death I therefore arranged to give up the house. Reserving valued relics and such few pieces of furniture as promised to be useful in London, and distributing the rest among my relations, I surrendered the key to the landlord."

It was at this time, or shortly afterwards, that Herbert Spencer gave the electrical apparatus to George Holme, who as a youth of sixteen or seventeen had saved him from drowning and had been his friend ever since. George Holme afterwards became a well-to-do manufacturer and was Mayor of Derby in 1875. An edition of Spencer's works was inscribed: "From Herbert Spencer to his old friend George Holme, without whose courageous aid rendered in boyhood neither this work nor any of the accompanying works would ever have existed." On the death of George Holme the apparatus was left to his grandson, George Hyde. At his death his widow gave it to their nephew, Mr. Colin Hyde Bennett, the present owner, whose parents still live in Derby. It is to their courtesy that the present writer owes the opportunity of inspecting the apparatus, as well as the supreme satisfaction of firing the electrical pistol, which shot its cork vigorously across the room.

FREDK. W. SHURLOCK.

6 Glenhouse Road,
Eltham, S.E.9,
April 14.

Convection of Heat in Fluid Flow through Pipes.

IN his letter in NATURE of April 9, p. 527, Mr. H. F. P. Purday proposes to add yet another purely empirical formula to the many already proposed for representing the transfer of heat from a tube to a fluid passing through it. I cannot believe that much progress is possible along this line. Any further advance must, I think, be based on physical considerations, which will indicate the form of the functions involved, as to which the theory of dimensions can give us no information whatever.

It is now, I think, generally agreed, that in the turbulent flow of a fluid through a pipe there is always a layer which creeps in viscous or laminar flow along the surface of the tube, whilst the remainder of the cross-section of the tube is filled with turbulent fluid. Osborne Reynolds, many years ago, gave a rational expression for the transfer of heat from the interior surface of the viscous layer to the turbulent core. Across the viscous layer, heat transfer can only take place by conduction. If we knew its thickness we could find a complete expression for the transfer of heat from the hot wall to the fluid. Such an expression must necessarily involve at least two terms, since the transfer is effected in part by conduction and in part by convection.

Whilst it does not seem possible to calculate directly the thickness of the laminar film, it is possible from physical considerations to fix an upper limit to its maximum possible thickness. The actual thickness must be less than this, so that if the limiting thickness be found, as above indicated, the actual thickness will be ϕt, where t is the limiting thickness and ϕ a coefficient to be determined by

experiment, and which has, it will be seen, a definite physical signification.

To my surprise, an examination of the experimental data indicated that ϕ was sensibly constant, the figure found being 0·55. I fully expected that ϕ would increase as the critical velocity was approached; but the experimental evidence did not bear this out.

Incidentally, I was able to show that when the fluid traversing the tube was water, which in practice always contains dissolved gases, there was a second 'critical' condition besides that corresponding to the critical velocity. Up to a temperature of about 80° C., gases are but slowly liberated from water; but if the pressure be atmospheric, they come off freely if this temperature be exceeded. This results in the breaking up of the laminar film, and there is then, as experiment shows, a sudden and large reduction in the resistance to heat transfer when the wall temperature rises above some 80° C.

The complete research was published in *Engineering* of July 6, 1923, *et seq.* H. M. MARTIN.

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Croydon.

The Anomalous Flocculation of Clay.

THIS is a rather belated reply to Prof. Comber's letter to NATURE of Sept. 18, 1926 (vol. 118, p. 412), but we should like to refer to one or two points. It is a little difficult to be sure of what Prof. Comber means by the statement that "Flocculation of clay by calcium salts is anomalous when considered in the light of prevalent theories," when, perhaps, no theories on this question can be said to be prevalent. With regard to the facts (on which the theories ought to be based) we profess to have established the following:

(1) Clay flocculated by dilute hydrochloric acid and then purified from electrolytes by dialysis or other means is nearly free from exchangeable bases.

(2) Such clay (containing only 0·1 per cent. of replaceable calcium) is readily flocculated by sodium hydroxide: this seems in direct conflict with the last paragraph of Prof. Comber's letter. Further, kaolin and pure silica containing no exchangeable calcium can be readily flocculated by sodium hydroxide.

(3) It is more easily flocculated by the chlorides than by the hydroxides of either sodium or calcium where the concentration of the base does not exceed 0·5 N and 0·002 N respectively.

(4) At higher concentrations it is more easily flocculated by hydroxides than chlorides, and this is true both for sodium and for calcium.

(5) In the case of suspensions of pure silica containing only particles less than 2μ diameter, flocculation cannot be brought about by the chlorides at concentrations up to normal, whilst in the case of the hydroxides, $N/60$ and $N/10$ are sufficient for calcium and sodium respectively to produce flocculation in one hour.

(6) The flocculation of silica differs from that of clay in that the former is only flocculated by sodium or calcium chloride in an alkaline medium. The concentration required decreases with increasing alkalinity, and this also holds for clay above a pH of about 9. If, however, a small amount of aluminium hydroxide is precipitated on the silica, there results an electro-negative suspension of which the behaviour towards flocculants is remarkably similar to that of clay. In particular, it shows the phenomenon of successive flocculation, deflocculation, and flocculation on the addition of increasing quantities of alkaline solutions of sodium chloride, as described in the case of clay in our previous letter to NATURE (May 1, 1926, p. 624).

These are the facts so far as we have gone: silica and clay are certainly different in respect to flocculation phenomenon, but it is better not to call either anomalous. A. F. JOSEPH.
H. B. OAKLEY.

Wellcome Tropical Research Laboratory,
Khartoum, Mar. 15.

The Financing of Research Associations.

MANY of the industrial research associations of Great Britain have, in the opinion of the leaders in their respective industries, amply justified their existence. In view of the possible cessation of their State subsidy, these associations must consider means for raising revenue adequate for their continuance on a permanent basis.

The present method of soliciting annual donations from firms and trade associations leaves a research association in a recurring state of financial uncertainty which makes it difficult to plan any extensive or expensive research. The refusal of some firms in the industry to co-operate is a further handicap.

In the case of some associations, the time is ripe for ascertaining the amount of support likely to be provided from the industry itself and from the users of its products. I include the users because it often happens that they reap much of the financial benefit arising from the work of the association, as, for example, when this work results in the improved efficiency of electrical generating or distributing plant.

In industries in which a desire exists for the continuance of their research associations after the expiry of the subsidy, it would be necessary to estimate the amount needed to place the work on a satisfactory basis, and to ensure that this amount can be secured, as a minimum, for, say, ten years. It seems reasonable to ask the firms interested to agree to a voluntary levy of a small percentage of the turnover of each of them. In some industries one pound for each thousand pounds of turnover would provide sufficient revenue, provided the scheme were widely supported. No firm need disclose the amount of its turnover except, in confidence, to a chartered accountant.

Such a scheme for placing the finance of the associations on a more permanent basis is not likely to be approved by the financial heads of firms without pressure from those concerned in the continuance of co-operative research; the purpose of this letter is to impress on those readers of NATURE so concerned the advisability of considering the advantages and difficulties of such a scheme, and, if approved, of pressing it on the notice of those who would need to be influenced to subscribe.

ROBT. W. PAUL.

Surface Film of Aluminium.

IT is generally believed that the surface of aluminium is normally covered with a thin layer of aluminium oxide or hydroxide, and that the metal possesses the property of forming this film on freshly cleaned surfaces. Bengough and Hudson (*Jour. Inst. Metals*, 21, p. 143) state, "the metal is normally covered with a layer of oxide," and Seligman and Williams (*Jour. Inst. Metals*, 23, p. 169), "It is generally assumed that aluminium exposed to air is covered by a film of oxide or hydroxide which prevents

the complete oxidation of the metal. The film is invisible and, so far as the writers are aware, no direct evidence of its existence on aluminium ordinarily treated has been adduced."

Until very recently we were in agreement with Seligman and Williams regarding the absence of direct evidence. During the course of experiments made with the object of studying the properties of films produced on aluminium by the Bengough anodic process, we found it was possible to isolate the films by the following method :

The aluminium, preferably in the form of thin sheet, is cut into narrow strips, and one or more of these strips is heated in a tube in an atmosphere of dry hydrogen to a temperature of 300° C. Dry hydrogen chloride is then passed through the tube. The metallic aluminium exposed at the cut edges of the strips reacts with the hydrogen chloride to form aluminium chloride, which sublimes and deposits in the cooler parts of the tube. Ultimately all the metallic aluminium is so removed and the surface films remain, together with some of the impurities in the aluminium.

By the above method it was found possible to obtain a film from normal commercial aluminium sheet. The natural film liberated in this way was extremely delicate, tended to curl, and was small in amount, but appeared to be continuous.

H. SUTTON.
J. W. W. WILLSTROP.

Royal Aircraft Establishment,
South Farnborough, Hants,
April 7.

Formation of Organic Acids from Sugars by *Aspergillus niger*.

UNDER the above title we recently showed (*J. Chem. Soc.*, 1927, 200) that when *Aspergillus niger* is grown on citric acid as sole source of carbon, the formation of acetone, malonic acid, and glyoxylic acid can be demonstrated. The production of citric acid from potassium saccharate and the mould may be detected, under careful control, by Denigés' test and by oxidation to acetone. It appears, therefore, that saccharic acid may possibly be an intermediate product in the formation of citric acid from glucose by *Aspergillus niger*, as was suggested by Franzen and Schmitt in the case of the citric acid in plants (*Berichte Deutschen Chem. Ges.*, 1925, 58, 222).

This view has now received further support from our recent observation that when *A. niger* is grown on glucose as sole source of carbon, the solution contains saccharic acid, which may be isolated as the potassium hydrogen salt. This has been identified (1) by titration with standard alkali, (2) by determination of potassium, and (3) by determination of thallium in the corresponding thallium hydrogen salt. Apart from the observation of Grüss (*Jahrbücher für wiss. Botanik*, 1926, 66, 155, 171, 177) that saccharic acid is formed by the action of the yeasts *Anthomyces Reukaufii* and *Amphiernia rubra* on glucose, this would appear to be the only recorded instance of the production of this acid by micro-organisms.

Grüss employed a medium containing glucose and traces of peptone, asparagine, potassium tartrate, and mineral salts, and the saccharic acid was identified microscopically as the cæsium hydrogen salt.

F. CHALLENGER.
V. SUBRAMANIAM.
T. K. WALKER.

Municipal College of Technology
and the University,
Manchester.

The Supposed Law of Flame Speeds.

IN NATURE of Feb. 12, p. 238, Dr. W. Payman and Prof. R. V. Wheeler reply to my letter in the issue of Jan. 8. They agree that deviations from the law of speeds may be expected if one of the combustibles in a complex mixture interferes with the burning of another, but claim that the deviations are small.

The examples I gave were carbon monoxide—hydrogen—air, and carbon disulphide—ethyl ether—air mixtures, but similar effects are obtained when ether is replaced by any one of a large number of combustibles. With regard to the first example, I quote Dr. Payman (*Jour. Chem. Soc.*, 1919, 115, 1456) : ". . . in the present research the maximum speed of uniform movement of flame in mixtures of carbon monoxide and air is found to be *about half* the value calculated, making use of the values determined for hydrogen—air and hydrogen—carbon monoxide—air mixtures." Such a difference between the calculated and experimental values would argue more than a *small* deviation from the law of speeds.

The same conclusion can be drawn from my own determinations of speed of flame in carbon disulphide—second combustible—air mixtures. Here the 'effective' speeds of the carbon disulphide—air mixtures, as calculated from the complex mixtures, are often less than half those directly determined. This phenomenon can scarcely be ascribed to a 'cool' flame, as it occurs even with a carbon disulphide—air mixture proportioned to give perfect combustion. An account of these experiments is being prepared for publication.

A. G. WHITE.

45 Caledonia Road,
Saltcoats.

The Origin of the Earth's Surface Structure.

SOME further explanation of certain points in our letter in NATURE of April 9 on the above subject is desirable.

Our argument concerning the mode of origin of the earth's surface structure does not turn upon whether dunite or eclogite forms the deeper substratum ; for these substances differ but little in radioactivity and are alike in density. The uranium and thorium content of dunite (*Phil. Mag.*, May 1924) is considerably below that of the plateau basalts, and their content of potassium is practically *nil*. Hence, whether eclogite or dunite occupies the depths, we are justified in concluding that density and radioactivity vary inversely in the earth's outer regions : the intrinsic density increasing and the radioactivity diminishing downwards. If Prof. Holmes's suggestion that the lower part of the continents is dioritic in character is correct (NATURE, Oct. 23, 1926), the rule still applies. Our preference for eclogite as occupant of the depths is founded on the simplification involved, seeing that this substance is to be expected therein as a piezocrystalline form of basaltic magma ; for such it undoubtedly is.

While our contention that seismic evidence is not opposed to the existence of deep-seated eclogite is true, it is also true that its presence has not as yet received the same experimental support as the presence of dunite has received. We believe the experiments of Adams and Gibson have not so far been extended to eclogite. There is much to justify the expectation that when they are so extended the results will be similar.

J. JOLY.
J. H. J. POOLE.

The Modern 'Zoo.'

ALMOST simultaneously there have been made announcements of two proposals of great importance in the evolution of the modern zoological garden in Britain. The Zoological Society of London has acquired an estate of 400 acres, lying under the Dunstable Downs, midway between Tring and Luton, which is to be developed on lines very different from those familiar in Regent's Park; and the Zoological Society of Scotland proposes to develop its park to the crest of Corstorphine Hill, over 47 acres which it now possesses but which have hitherto been used as a golf course.

Photo] [*J. C. M'Kechnie*

FIG. 1.—The Polar Bear enclosure in the Scottish Zoological Park.

In magnitude the two ventures are scarcely comparable, but both are at one in indicating that the future of zoological garden development in Great Britain lies along the lines of spaciousness and freedom, and that the old-fashioned 'zoo,' cramped in space and overstocked in kind, meeting neither the needs of the animals nor the demands of the Nature lover, is on the path to extinction.

The change marks a revolution in the attitude of the public towards captive animals during the past century. The 'zoo' fashion swept over Europe in the early half of the nineteenth century: the London Zoo in Regent's Park was founded in 1828; the Dublin garden in 1830; Clifton, Bristol, in 1835; Belle Vue, Manchester, in 1836; Amsterdam in 1838; Antwerp in 1843; and Berlin in the year following. The people, animated by a sensation-loving curiosity rather than by a love of Nature, wished to see at close quarters, but in conspicuous safety, the fiercest and the rarest of animals, and the old zoos met the demand by erecting closely packed cages and stout iron bars. The public no longer sets so high store upon the cramped animal, spending a lifetime in an endless promenade of an inadequate cage, and a growing responsibility towards the animals themselves, as well as a developing artistic perception, have led to the modern ideal of surroundings approaching as closely as possible to the natural environment, in which animals may display their graces of movement and repose in the greatest permissible freedom. It is interesting to recall that the prime movers in this beneficent revolution were not the great public zoos, but the owners of private collections.

The Zoological Society of London has been fortunate in its choice of new ground. The natural slope of the Ashridge estate, rising on one side rather abruptly from the 500 ft. contour to more than 700 ft. above sea-level (and half the entire area exceeds the latter altitude), gives scope for wide outlooks and fine panoramic effects, which will add repose and nobility to their tenants. So far as possible, the natural amenities of the site will be retained, and, in place of unsightly barriers, concealed ditches and sunk fences masked by natural scenery will separate the different groups of animals. A chalk foundation affords a medium readily excavated, so that the creation of attractive

caves and shelters and dividing trenches becomes largely a matter of artistic planning and moderate expenditure.

In this handsome park the Society proposes to instal the larger and more hardy of its animals, its breeding and recuperating animals, and the majority of its duplicates. But apart from foreign imported creatures, Ashridge should become a great British sanctuary, tenanted by native birds, and exhibiting, congregated as they cannot be seen in any other part of the country, the few mammals which still exist, and those which formerly existed, in Britain. The stock in the London Zoo will benefit by reduction, and Regent's Park will become the home of a typical synopsis of the animal kingdom, and of the more delicate creatures which demand special conditions of temperature, feeding, and the like.

The proposed extension of the Scottish Zoological Park is less of an adventure in more ways than one, for since its inception in 1912 the Park has all along been developed on modern lines, and the inclusion of the remainder of its 74 acres, nearly twice the extent of the Regent's Park Zoo, is but the fulfilment of a project which the Council has had in view from the beginning. Nevertheless, it is an impressive scheme. The addition will carry the Park to the ridge of Corstorphine Hill at an altitude of 500 ft. above sea-level, and, while still retaining the southern exposure which has meant so much for the welfare of the animals, will throw open a fine northern prospect across the Firth of Forth and its islands to the hills of Fife and the Highlands of Perthshire. The ground is less amenable to artificial treatment than the chalky subsoil of Ashridge, for the rock is hard and costly to excavate; but the gain is greater than the loss, since Nature has already carved the summit into rocky ridges and hillocks, affording sites which will exhibit at their best such mountain creatures as wild sheep, goats, chamois, and the like. On the lower ridges it is proposed to excavate dens and shelters for carnivores, and to give over a portion to native British mammals, while the pasture land will become ranges for native and foreign deer, bison, etc.

The sole obstacle to the development of this ground is a financial one. Last year the takings showed a modest surplus of £2000, and since the opening of the Park, all its surplus income, amounting to more than £10,000, has been spent in improvements which have added to the comfort of the animals and the attractiveness of the exhibits. To lay out and utilise the new ground, and to provide further improvements in some of the existing enclosures for animals, it is estimated that £25,000 will be required. Since such a sum cannot be obtained from the present income of the Park, the Council has issued an appeal for that amount, so that the Park may become a "National Institution, unrivalled for beauty of site and natural amenity." In furtherance of the scheme, it is announced that a mid-summer carnival and fête will be held in the Park in June. The conspicuous success already attained in the development of a modern zoological park in Edinburgh indicates that the new effort of the Zoological Society of Scotland is worthy of all support.

The Theory of Strong Electrolytes.

THE general discussion on "The Theory of Strong Electrolytes," organised by the Faraday Society at Oxford on April 22 and 23, was rendered noteworthy by the foreign guests who were able to attend and to take part in the proceedings: Bjerrum, Brönsted, and Christianssen from Copenhagen, Fajans from Munich, Hevesy from Freiburg, Hückel (a former colleague of Debye) from Göttingen, Onsager (a present colleague of Debye) from Zurich, Remy from Hamburg, and Ulich (a colleague of Walden) from Rostock, represented the European universities, whilst America was represented by Harned from the University of Pennsylvania and Scatchard from the Massachusetts Institute of Technology. The delegates enjoyed the hospitality of Exeter, Jesus, and Lincoln Colleges, and the informal discussions carried on there were not the least valuable features of the meeting.

It is now forty years since Arrhenius effected a far-reaching change in the theory of aqueous solutions by introducing the conception of electrolytic dissociation, and there can be little doubt that similar importance attaches to the recent development, by Milner, and more recently by Debye and Hückel, of theories based upon the conception of 'complete ionisation' of electrolytes. This conception, although devised in the first instance to explain the behaviour of electrolytes in solution, has received important support from the study of crystalline salts, which has shown that most of them can be pictured as aggregates of oppositely charged ions, in which individual molecules cannot be detected, as well as from the electronic theory of valency, which has provided an explanation of the inability of these ions to effect the transfer of electrons which would convert them into neutral molecules.

The chief weakness of Arrhenius's theory lay in the fact that, although the dissociation of weak electrolytes on dilution with water was in accord with the law of mass action, this law broke down completely in the case of strong electrolytes, *i.e.* of all the common salts, as well as the stronger acids and bases. Many formulæ have been devised in the hope of discovering a law of dilution which should be applied to these perfectly normal, but obstinately intractable, electrolytes; but modern theory has turned back to an old expression of Kohlrausch, $\Lambda_c = \Lambda_o - a\sqrt{c}$, according to which the equivalent conductivity Λ_c, at concentration c, is less than that at concentration 0, by an amount $a\sqrt{c}$ which is proportional to the square root of the concentration. This law, which can be tested

by plotting Λ against $\sqrt{c}$, has been verified for a large number of salts both in aqueous and in non-aqueous solutions, and appears to have a wide range of validity; but the constancy of the index was challenged in a paper by Ferguson and Vogel, who assert that the index varies from 0·38 in barium bromide to 0·635 in lithium perchlorate, although the average for thirty-three salts is only just below 0·5. The theory of Debye and Hückel has the merit of deducing Kohlrausch's law from the fundamental laws of electrostatics, so that the index $\frac{1}{2}$ appears as an echo of the index -2 of Coulomb's law.

The theory of Debye and Hückel is based on the postulate that each negative ion in a solution is surrounded by a region containing an excess of positive ions, and conversely. Such a distribution is quite practicable, since it is realised in the lattice of the crystalline salts; thus, in the case of sodium chloride, the closest neighbours of a sodium ion are 6 chloride ions, followed by 12 sodium ions at a rather greater distance, and then by 8 more chlorine ions at a slightly greater distance still. In electrolysis, this surrounding atmosphere of ions is drawn through the solution, and creates an increased frictional resistance by dragging the solvent with it, as in the phenomenon of electrophoresis. Moreover, since the atmosphere of oppositely charged ions lags behind the ion under consideration, as soon as it begins to move, a retarding electrostatic potential will be set up, the strength of which will depend on the rapidity with which the excess of oppositely charged ions is dissipated in the rear of the moving ion and collected in the new region into which it is advancing. The calculation of the magnitude of these effects presents a very difficult problem in statistical mechanics, but it can be shown in both cases that the resultant decrease of equivalent conductivity is proportional to the square root of the concentration. Kohlrausch's law can therefore be explained as due to variations of ionic mobility, resulting from the phenomenon of interionic attraction, without requiring any variation in the number of ions involved in carrying the current.

The formulæ of Debye and Hückel give results which are not yet in precise numerical agreement with experiment, although a closer agreement is obtained by making use of a modification due to Onsager, in which (by allowing for the Brownian movement of the ions) the numerical factor is reduced in the ratio 1 : 0·586. It is, however, a fact of fundamental importance that the theory of interionic attraction has at last provided a physical basis for Kohlrausch's law, since the earlier theory of electrolytic dissociation led to an entirely different, and incompatible, relationship between conductivity and concentration. On the other hand, it is a disappointment to find the old warning repeated, and in a still more emphatic form, that the formulæ now used are only valid in 'dilute solutions,' and that a close concordance between theory and experiment is not to be looked for in solutions of greater concentration than $N/100$ or $N/1000$, since it was at least reasonable to hope that the new theory of strong electrolytes would be applicable to strong solutions also.

An important question was raised at the discussion as to whether the theory of strong electrolytes requires that *all* the ions must be free, even in solutions of high concentration. The momentary existence of pairs of ions which have insufficient kinetic energy to separate from one another appears to present no difficulty, and may perhaps be covered by the existing equations. Numerical calculations suggest that the number of these neutral doublets is small; but as the new formulæ are only valid for solutions of extreme dilution, no experimental verification of these calculations is possible. On the other hand, Walden's observations of the small conductivity of salts such as $[NEt_4]^+I^-$, when dissolved in solvents of low dielectric capacity, indicate that the proportion of electrically neutral doublets may under some conditions be quite as high as that of the undissociated molecules of Arrhenius's theory. The same conclusion can be deduced in a still more emphatic form from the fact that potassium bromide behaves as an insulator when dissolved in liquid bromine, although phosphorus pentabromide acts as an electrolyte in this solvent.

During the discussion the position was generally adopted of classifying as 'weak electrolytes' all those compounds in which real molecules can be formed from the ions. This classification can scarcely be valid, since hydrochloric acid has all the properties of a 'strong electrolyte,' in spite of the fact that anhydrous hydrogen chloride has just as much claim as hydrogen cyanide to be regarded as a covalent compound. These neutral molecules are, however, so readily ionised by contact with water that it is only in concentrated solutions that they become sufficiently numerous to produce a marked vapour pressure. Since the theory of Debye and Hückel only applies to dilute solutions, it may be taken for granted that no difference would be detected by means of it between a strong electrolyte which is wholly ionised even in the solid state, and one in which the real molecules of the crystal are resolved almost completely into ions by the influence of an ionising solvent; in a hydrocarbon solvent, on the other hand, both types of solute would behave as weak electrolytes.

The problem of solvation was also discussed. Mr. R. H. Fowler expressed the view that, since water behaves as a dipole, it must be attracted towards the ions, and expecially to those of small radius. A pressure gradient would thus be set up which would check the approach of all other ions, whether of similar or of opposite sign. The orientation of the water molecules would be reversed with the sign of the ions, as suggested by Ciamician in 1891, and formulæ expressing this view were included in a paper by Ulich.

The applicability of Stokes's law to ions was repeatedly challenged, as also was Walden's relation between mobility and viscosity; but it seems likely that these relations will continue to be

used in future arguments in reference to the mechanism of conductivity, if only as providing a standard from which deviations can be measured. On the other hand, it is equally clear that all such arguments will henceforth be dominated by the theory of interionic attraction, in one form or another. The Faraday Society is therefore to be congratulated on having secured so lively a discussion of the subject. This discussion, with the twenty-seven papers circulated before the meeting, will provide the basis for a most valuable report. T. M. L.

Obituary.

DR. ABRAHAM LEVIN.

THE tragic death of Dr. Abraham Levin on April 20, within a few minutes of leaving his laboratory at Plymouth, deprives physiology of a young and brilliant worker. A man of versatile talents, he showed from an early age a remarkable mechanical ingenuity and an extraordinary aptitude for engineering. This subject he studied in Rome, but long-continued ill-health, exaggerated in later years by privation during the Russian revolution, prevented him pursuing this study further. He therefore turned to other less exacting activities and studied music at Kieff with great success.

At the outbreak of War, Levin took up the study of medicine at the Crimean University at Simferopol, where he took his M.D. Prof. Gurvitch recognised his ability and made him his assistant. His mechanical bent resulted in the invention of a highly ingenious sphygmometer. Being able to come to England in 1924, his tireless mental energy found an ideal outlet in research with Prof. A. V. Hill at University College, London, and at the Marine Biological Laboratory, Plymouth. Levin's mechanical ability here stood him in the greatest service and enabled him to perform many beautiful experiments on the viscosity and elasticity of muscle and on the action current in nerves, as his published work shows.

Unfortunately, much of Levin's work is not yet finished; he died in the middle of a series of experiments on the action current in Crustacean nerve, which promised to yield results of the highest importance to the theory of nervous conduction and excitation. He was a man of the highest promise in his field of research, and his early death is a very great loss. C. F. A. P.

THE issue of the *Physikalische Zeitschrift* for Feb. 15 devotes twelve pages to the obituary address delivered in the hall of the Physikalisch-Technische Reichsanstalt at Charlottenburg on Dec. 18 by Dr. F. Henning, following on the death on Sept. 19 of his friend and colleague Dr. C. F. L. Holborn, head of the Heat Section of the Reichsanstalt. Dr. Holborn was born at Göttingen on Sept. 29, 1860, and after attending the local Realschule entered the University in 1879, and passed the government examination for teachers in 1884. He elected not to teach, but entered the Observatory as assistant to Schering in the terrestrial magnetism department, and in 1887 took his doctor's degree with a dissertation on the daily variation of the magnetic elements. In 1890 he joined the Reichsanstalt as assistant and rose gradually to be head of the Heat Section. For a time in 1924 he acted as director of the establishment, and the date of his retirement from office was put three years later than the usual age of sixty-five years. His work on the temperature scale and on the thermal properties of gases has proved of great value for both science and industry.

WE regret to record the death of Sir Philip James Hamilton-Grierson, who died suddenly on Monday, April 25, at Kemnay, Aberdeenshire, at the age of sixty-six years. He was educated at Cheltenham College and Merton College, Oxford, taking his degree in 1876. A member of the Scottish Bar, he held a number of legal appointments in Scotland, was knighted in 1910 and received the honorary degree of LL.D. from the University of Edinburgh in 1920. In addition to editing a number of legal works, he was the author of several articles which appeared in Hastings' "Encyclopædia of Religion and Ethics," but his most important contribution to scientific literature was "The Silent Trade: A Contribution to the Early History of Human Intercourse," a valuable book in which he brought his legal training to bear upon the facts and underlying principles involved in primitive systems of economics and exchange.

WE regret to announce the following deaths:

Dr. A. W. Brightmore, engineering inspector at the Ministry of Health and formerly professor of structural engineering at the Royal Indian Engineering College, Cooper's Hill, on April 20, aged sixty-two years.

Dr. W. Collingridge, formerly Medical Officer to the Port of London and the City of London, on April 29, aged seventy-three years.

Prof. W. H. Dall, palæontologist of the U.S. Geological Survey since 1885 and honorary curator of the Division of Mollusks of the U.S. National Museum since 1869, on Mar. 27, aged eighty-one years.

Mr. E. T. Dumble, consulting geologist in Texas and formerly State geologist, who contributed notably to our knowledge of the economic geology of the Pacific slope, on Jan. 27, aged seventy-four years.

Dr. Charles E. Marshall, director of the graduate school and professor of microbiology at the Massachusetts Agricultural College, on Mar. 20, aged sixty years.

Prof. C. C. Nutting, professor of zoology in the State University of Iowa, and vice-president in 1902 of Section F of the American Association for the Advancement of Science, who was known for his work in marine systematic zoology, and particularly on the Cœlenterata, on Jan. 23, aged sixty-eight years.

Prof. E. H. Starling, F.R.S., Foulerton research professor of the Royal Society and formerly Jodrell professor of physiology in the University of London, on May 2.

News and Views.

A STRONG commission, commencing under the chairmanship of the late Lord Milner, and comprising among others Sir Arthur Shipley, Sir Daniel Hall, Sir John Farmer, Dr. A. W. Hill, and Mr. F. B. Smith, has lately reported ("Agricultural Research and Administration in the Non-self-governing Dependencies." Report of Commission, Cmd. 2825, London, H.M.S.O., 1927. 2*s*.) on the question of the difficulty experienced in recruiting officers of satisfactory ability for research and administrative work in the non-self-governing colonies of the British Empire. The difficulty is largely put down to lack of general interest in the development of these colonies, though they form a sixth of the area of the Empire, and have 50 million inhabitants. An interim report has already been issued, upon which action has been taken by establishing a number of scholarships, similar to those provided by the Empire Cotton Growing Corporation, whose incumbents, after taking a degree similar to the Cambridge Science Tripos, Part II., shall spend one year in special training in Great Britain and one year in the Imperial College of Tropical Agriculture in Trinidad. In this way it is hoped to form a kind of reservoir from which the colonies may draw trained men, who will have had at any rate one year of tropical experience under proper guidance.

THE second part of the report before us deals with the collection and dissemination of information about the research and other work that is in progress in the different colonies, and it is recommended that a kind of central clearing-house, upon the lines of the Imperial Bureaux of Entomology and Mycology, be established in London for the purpose of collecting, abstracting, and compiling and issuing a periodical summary of information. The third part then goes on to deal with the organisation of research, and it is recommended by a majority of the Commission that a central advisory council be established in England, the chairman of which (a distinguished man of science) and secretariat shall be full-time officers, the former also travelling into the various colonies to see at first hand what is being done and to advise upon the spot. The duty of the council would be to collect information as to the work going on in every dependency, and to advise and criticise. The whole report is worth careful perusal.

DR. R. H. PICKARD has been appointed Director of the British Cotton Industry Research Association in succession to the late Dr. A. W. Crossley, who resigned the post shortly before his death on Mar. 5 last. During the past seven years Dr. Pickard has been Principal of Battersea Polytechnic, and to the responsible duties of this post he has added those of the directorship of the British Leather Manufacturers' Research Association. From 1899 until 1907, Dr. Pickard was head of the Chemistry Department of Blackburn Municipal Technical School, and afterwards principal of the same Institution until his appointment to Battersea. During this period Dr. Pickard, in collaboration with his staff, published numerous papers in the *Journal of the Chemical Society*; for the most part these deal with the preparation of the isomeric borneols and menthols in a state of optical purity, and also with the synthesis and extended examination of a very large number of optically active organic compounds of simple chemical constitution. Considered as a whole, this work forms one of the most important and systematic attempts which have been made towards the solution of the complicated and difficult problem of the relationship between chemical constitution and optical activity. This record as a scientific investigator, combined with the experience gained during the tenure of administrative posts of considerable responsibility, affords ample assurance that the various activities of the British Cotton Industry Research Association will continue to be maintained at a high level in the hands of the new Director.

DR. E. V. APPLETON'S discourse delivered at the Royal Institution on Friday, April 29, was entitled "Wireless Transmission and the Upper Atmosphere." It is now becoming more and more evident, he said, that the atmosphere has a profound influence on the transmission of radio waves through it and thus on radio telegraphy generally. The earliest indication of atmospheric influence was Marconi's successful transmission across the Atlantic in December 1901. The distances previously accomplished by Marconi were so short as to be explicable on the simple hypothesis that the radio waves travelled in straight lines. But communication to America, as the late Lord Rayleigh was the first to realise, raised a new question. Could the waves bend round the protuberance of the earth, as sound waves bend round a corner? Lord Rayleigh and others investigated the problem mathematically, and their results showed that some influence other than ordinary diffractive bending was at work. We now know that this other influence is the so-called Heaviside layer of electricity in the upper atmosphere, which guides long radio waves round the earth's curvature. All recent work has tended to prove the Heaviside layer theory, and within the last two years it has been shown that the signal fading, with which many broadcast listeners are familiar, is also due to the action of this layer. This signal fading is most marked at a distance of 100 to 150 miles from the transmitting station and is due to the interfering action of the waves sent back to the ground by the Heaviside layer.

EXPERIMENTS made in conjunction with the B.B.C. engineers and the National Physical Laboratory show that the height of the Heaviside layer is about 70 km., rising to 120 km. during the night and falling to its lower value with the advent of sunrise. The layer is only found to reflect broadcast waves copiously at night, there being practically no reflection during the day-time, when the ground waves only are received. Experiments on the very short wave-lengths have shown that the ground waves die out very rapidly with increasing distance, so that reception at great

distance is accomplished only by means of waves deflected by the upper atmosphere. But with decreasing wave-length the amount of bending the atmosphere can accomplish becomes less and less, so that with very short waves a penetration of the Heaviside layer becomes feasible, especially at night when the amount of electricity in the upper atmosphere is least. Waves of the order of one metre in wave-length would penetrate it and thus be of no use for long-distance communication on the earth. A surprising result has recently been found in the effects of magnetic storms on radio transmission. Such storms interfere very seriously with long-distance short wave transmission, and yet with very long waves the signals are stronger than usual. It is possible to explain these results in terms of the Heaviside theory if we assume that a magnetic storm increases the electricity in the layer. In such a case the short waves which have to penetrate the layer to be bent gradually back to the ground are more strongly absorbed, because they are returned at lower levels where the friction experienced by the electricity is larger. On the other hand, the long waves are truly reflected by the layer at its surface, and an increase in the amount of electricity in the layer increases the amount of this reflection.

AN exhibition of modern British architecture was opened by Viscount Peel at the Royal Institute of British Architects' galleries on April 26. Organised by the Institute, this constitutes a new event to be repeated annually. It may be asked why, with the architectural room just opened at the Royal Academy, such a new departure is necessary. The explanation is twofold—the limited space at the Academy and the decision of the promoters of this new exhibition to admit photographs. Lord Peel in his speech referred to the Swedish and American exhibition of architecture previously held by the Royal Institute, and to the value of arousing the dormant artistic tastes possessed by a large section of the public by the display of good examples of current work; he also referred to the danger of producing rural slums by the indiscriminate erection of small houses without adequate artistic advice. The exhibits consist mainly of photographs, though there are a number of important buildings represented as perspectives in colour. Most of the works present domestic architecture, and it is noticeable that the grandiose buildings of the past have given way to smaller and simpler types of houses. Public buildings are also well represented, and there are examples of schools and other institutions; but visitors expecting to see interiors showing the application of the architect's work to the technical problems required to meet the needs of the man of science will be disappointed. Such a display is, however, apparently outside the scope of the exhibition. The galleries will remain open until June 3.

IN a lecture given under the auspices of the British West India Committee on April 28, Mr. Ormsby-Gore, Under-Secretary of State for the Colonies, described the work of the Empire Marketing Board. Its tasks, he said, are to bring home to every section of the community the idea and the significance of the British Empire and its resources, and to mobilise the forces of research, both economic and scientific, to assist in the better production, distribution, storage, and marketing of Empire products. To ensure the greatest possible co-ordination of research work and to guard against unnecessary overlapping, a small Research Committee has been formed. Applications for grants for scientific research are either received through the appropriate Government department or referred by the Committee to the appropriate department for consideration and advice. Grants are in general limited to researches which are likely to be of importance to the Empire as a whole and not merely of local importance: for example, research in animal nutrition and in entomology. The latter field of research is of the utmost importance, as it is estimated that one-tenth of the world's crops are destroyed by insect pests yearly. The Board is sufficiently impressed with the results already achieved in connexion with the biological control of insect pests to make a grant of £15,000 a year for five years for the establishment and maintenance in England of a sort of 'parasite zoo,' where parasites destructive of insect pests can be bred and distributed wherever needed throughout the Empire. By such work as this it is hoped that the Board will earn the support of all political parties in Great Britain and also that of the various Governments of the Empire.

THE spring floods of the Mississippi have attained unusual proportion this year. They are due to the melting of snow in the northern part of the vast drainage area of the river in March, combined with the spring rains of April. A recent article in the *Times* points out how these floods periodically attain dangerous proportions, threatening all the lower flood plains and delta of the river, which are protected from normal inundation by levees or embankments, partly of natural growth and partly of artificial construction. The last severe floods on a large scale were in 1912, and some twenty-two years earlier the floods were so heavy that the levees protecting New Orleans were breached and parts of the city inundated. This year the floods of the two rivers Arkansas and Yazoo, dammed back by the main torrent of the Mississippi, have already flooded great areas. But the most serious danger lies in the rise of water in the delta where New Orleans lies, protected by levees, ten to fifteen feet below the normal river level. In order to drain away the waters before they inundate the city, a breach has been made in the levee at Poydras, fifteen miles below New Orleans. Many miles of swamp and copse, chiefly the resort of trappers, have thus been flooded, but this measure may save New Orleans.

SIR ROBERT HADFIELD has generously provided a sum of about £200 towards the expenses of a member of the Institution of Mining and Metallurgy who would be of special service at the forthcoming Empire Mining and Metallurgical Congress in Canada, but

would not be able to attend without financial assistance. A committee was appointed by the Council of the Institution to allocate the grant, and has recommended that it be offered to Assist.-Prof. Bernard W. Holman of the Mining Department of the Imperial College of Science and Technology, South Kensington. Prof. Holman had a distinguished career as a student at the Royal School of Mines, he has made noteworthy contributions to the publications of the Institution of Mining and Metallurgy, and he is a good speaker in discussions. He spent 1925–26 in South Africa, where he made a good impression in the mining fields, and it is thought that his presence at the Canadian meeting will be useful in discussing the proposed programme for the third congress, to be held in South Africa, apart altogether from his value in discussing the purely technical papers which will be read.

THE Easter Conference of the Society for Experimental Biology was held in Cambridge on April 19 and 20 in the Physiological and Zoological Laboratories, by kind invitation of Profs. J. Barcroft and J. Stanley Gardiner. A number of very interesting papers were read during the three sessions of the Society. Dr. E. Delf gave an account of her recent work, showing the beneficial effect of small doses of ultra-violet light on plants. Dr. A. S. Parkes discussed the relation of oestrin to corpus luteum. Dr. G. V. Anrep explained the present position of our knowledge of cortical activities as elucidated by the study of conditioned reflexes. Mr. J. T. Saunders showed a beautiful series of experiments illustrating chemotaxis in ciliata to *pH*. Dr. E. D. Adrian gave an account of his recent work on the nature of the nervous impulse in sensory nerves. Mr. J. Gray gave a critical account of the rôle of gravity in cell-division. Prof. J. S. Huxley described the induction of premature metamorphosis in Echinus larvæ following chemical inhibition of the larval tissues. An important feature of the conference was a symposium on the relation of evolution to heredity and environment, conducted by Mr. G. C. Robson, Mr. J. B. S. Haldane, Mr. C. E. Diver, and Dr. F. A. E. Crew. The complete adequacy of natural selection acting on Mendelian variation was pointed out, particularly in the case of small variations, and the importance of the environment both in originating mutation and in selecting the variants was demonstrated.

A JOINT meeting of the vice-presidents and members of the Councils of the Institution of Fuel Technology and the Institution of Fuel Economy Engineers was held under the chairmanship of Sir Alfred Mond on Friday, April 29. As president of both Institutions, in November last, Sir Alfred Mond, having found a general desire amongst those interested in problems of fuel economy that the two existing Institutions should be merged into one, suggested terms of fusion. Under the terms of fusion finally accepted, the name of the merged Institutions will be "The Institute of Fuel"; and the present honorary secretaries of the parent Institutions will be joint honorary secretaries of the new Institute. At the meeting the final steps for the fusion of the existing Institutions and the inauguration of the Institute of Fuel were taken. Sir Alfred Mond expressed his great gratification that the fusion had been successfully accomplished. He said that the essential importance of the problems connected with fuel economy and fuel technology to the future of British industry is becoming increasingly recognised. The Government is vitally interested in the subject, and has appointed a National Fuel and Power Committee to investigate and consult upon the various problems in their many aspects. That Committee is progressing satisfactorily with its work, and it is of the utmost importance that there should be a unified Institution, important in numbers and personnel, to investigate, advise, and instruct the committee and the community on these highly technical matters. Mr. H. L. Pirie and Mr. Edgar C. Evans were afterwards appointed joint honorary secretaries of the Institute of Fuel.

THE first conversazione this year of the Royal Society will be held on Wednesday, May 11, at 8.30 P.M.

THE King has been pleased to nominate Dr. H. H. Dale, head of the Department of Biochemistry and Pharmacology, Medical Research Council, to be, for five years, a member of the General Council of Medical Education and Registration in the United Kingdom, in succession to Sir Nestor Tirard.

PROF. RICHARD WILLSTÄTTER will deliver the Faraday lecture of the Chemical Society on May 18, at 5.30 P.M., taking as his subject "Problems and Methods of Enzyme Research." The lecture will be delivered in the theatre of the Royal Institution, 21 Albemarle Street, London, W.1.

DR. R. J. TILLYARD, Chief of the Biological Department, Cawthron Institute, Nelson, New Zealand, has been elected an honorary member of the Entomological Society of Belgium. There are only six of these honorary members, and Prof. E. B. Poulton, Hope professor of zoology in the University of Oxford, is the only other British scientific worker among them.

AT the annual meeting of the Members of the Royal Institution, held on May 2, the following officers for the ensuing year were elected: *President*: The Duke of Northumberland; *Treasurer*: Sir Arthur Keith; *Secretary*: Sir Robert Robertson.

A PUBLICATION grant of £2500 is receivable by the Royal Society from H.M. Government during the current year. The grant is available for assisting the publications of other scientific societies, as well as for assisting the separate publication of books, memoirs, etc., of a scientific nature. Applications for grants will be adjudged by the Council of the Royal Society at its meeting early in July, but should be received before the council meeting of June 10. Applications from societies will be received by the secretaries of the Royal Society; those from individuals must be brought forward by members of Council.

THE Rockefeller Medical Fellowships for the academic year 1927–1928 will shortly be awarded

by the Medical Research Council, and applications should be lodged with the Council not later than June 1. These Fellowships are provided from a fund with which the Medical Research Council has been entrusted by the Rockefeller Foundation. Fellowships are awarded by the Council, in accordance with the desire of the Foundation, to graduates who have had some training in research work in the primary sciences of medicine or in clinical medicine or surgery and are likely to profit by a period of work at a university or other chosen centre in the United States before taking up positions for higher teaching or research in Great Britain. A Fellowship will have the value of not less than £350 a year for a single Fellow, and travelling expenses and some other allowances will be made in addition. Full particulars can be obtained from the Secretary, Medical Research Council, 15 York Buildings, Adelphi, London, W.C.2.

THE Physiological Society was founded in 1876, and its fiftieth Anniversary was in 1926. Owing to certain difficulties the celebration of the jubilee was deferred until this year. On Friday, May 13, the Society is holding its jubilee dinner. This will be followed by an ordinary meeting at Cambridge on Saturday afternoon, and on Sunday, May 15, Prof. and Mrs. Barcroft are giving a garden party in the Fellows' Garden of King's College.

PHYSICS generally will benefit considerably under the will of the late Prof. A. W. Scott, Phillips professor of science at St. David's College, Lampeter, who died on Mar. 7 at the age of eighty-one years. The University of Cambridge is to receive £7000 and the Royal Society £1000, the income from which is to be applied for the promotion of the physical sciences, and the British Association, the Physical Society, and the Institute of Physics are to receive £250 each. The residue of the estate, after sundry bequests, is to be divided into three equal portions, two of which are to go to the Universities of Oxford and Cambridge respectively, in each case "for the furtherance of physical science."

APPLICATIONS are invited for the following appointments, on or before the dates mentioned:—An assistant lecturer in chemistry at the Cardiff Technical College—The Principal, Technical College, Cardiff (May 14). A resident director of the National Gallery of Ireland—The Registrar, National Gallery, Dublin (May 19). A senior lecturer in education in the University of Manchester—The Registrar, The University, Manchester (May 19). A lecturer on pharmacology and therapeutics at St. Bartholomew's Hospital Medical College—The Dean, St. Bartholomew's Medical College, St. Bartholomew's Hospital, E.C.1 (May 20). Two research workers at the Low Temperature Research Station, Cambridge, for researches into the principles of canning foods of animal and vegetable origin—The Secretary, Department of Scientific and Industrial Research, 16 Old Queen Street, S.W.1 (May 21). A veterinary inspector under the Hertfordshire County Council and the Hereford City Council—The Clerk of the County Council, Shirehall, Hereford (May 21). A lecturer in chemistry in the University of the Witwatersrand, Johannesburg—The Secretary, Office of the High Commissioner for the Union of South Africa, Trafalgar Square, W.C.2 (June 1). A lecturer in biology and botany at the Birmingham Central Technical College—The Principal, Central Technical College, Suffolk Street, Birmingham. An assistant bacteriologist at the Wellcome Tropical Research Laboratories, Khartoum, and a laboratory assistant under the Sudan Government—The Controller, Sudan Government London Office, Wellington House, Buckingham Gate, S.W.1. A laboratory mechanic in the engineering laboratories of the Northampton Polytechnic Institute—The Principal, Northampton Polytechnic Institute, St. John Street, E.C.1. An analytical chemist—Crosse and Blackwell, Ltd., Soho Square, W.1.

Our Astronomical Column.

THE COMING SOLAR ECLIPSE.—It is evident that a keen and widespread interest prevails concerning this phenomenon, so rare in England. Many pamphlets on the subject are appearing. We have received one that is published by the Burnley Grammar School. Burnley lies within the totality zone but near its southern edge. The pamphlet was largely drawn up by members of the sixth form and gives in simple terms the conditions for eclipses in general and this one in particular. There is a warning that observers in Yorkshire should not select stations with high ground to the east of them, as morning mist is prevalent in such places. A large-scale map of the district (3 miles to 1 inch) includes Caton, Giggleswick, Settle, Stonyhurst, Colne, and shows the loci of different durations of totality, and of mid-eclipse at times 5 seconds apart.

Among the hints to photographers is the suggestion that attempts should be made to obtain colour photographs of the corona and prominences; this suggestion is also made by Mr. F. J. Hargreaves (*B.A.A. Journal* for March), who gives useful notes on the different screen plates and their ratios of exposure. Two small errata in the Burnley pamphlet may be noted: p. 13, for Sivar read Sivan; p. 15, the Norway eclipse was in 1851, not 1857.

Dr. Comrie has revised the eclipse calculations, using the latest available positions of the sun and moon. He finds that the track is likely to be 1 mile north of the Almanac position and the time 5 seconds later: the alteration is chiefly due to the deviation of the sun from Newcomb's Tables. With regard to some alarmist paragraphs on the subject in the daily press, it should be noted that uncertainties of similar amount are inseparable from all eclipse predictions, and that the only people appreciably affected are those very near the southern limit of totality, who should if possible move a little farther north.

The Astronomer Royal has announced that radio time signals will be sent out at 6^h, $6^h\ 15^m$, and $6^h\ 30^m$ (summer time) on the eclipse morning. These will be the usual 6 dots, the last of which is the exact minute.

All observers can do useful work by noting the exact time of the beginning and end of totality, correcting their watches by the radio signals, and indicating their exact locality, which may be done on a tracing from the 1-inch Ordnance map (or a larger scale). Merely saying "in Settle" or "in Burnley" is not near enough for this purpose.

Research Items.

THE KHALLAM.—Miss Erna Gunther has made a careful study of the Khallam, embodying existing literature, which is not extensive, in addition to her own personal observations. This has now appeared as No. 5, vol. 6, of the *Publications in Anthropology of the University of Washington*. The information obtained in the field was mainly collected at Jamestown, Washington Harbour, and Esquimault, but the Khallam formerly lived on the southern shore of the Strait of Juan de Fuca from the mouth of the Hoko River to Port Discovery Bay opposite Vancouver Island. They thus live in the region designated by Wissler as "the Salmon area," which extends along the Pacific Coast from Alaska to San Francisco bay. Their villages were for the most part on the coast, and their principal means of subsistence was sea food, especially salmon. Characteristically, agriculture was non-existent, vegetable food being obtained by gathering wild products—berries and roots. Each village, however, as a rule had one or two hunters, depending entirely on bow and arrow, who alone knew the mountainous country behind the shore. The villages consisted of a single row of rectangular houses with doors facing the water. The smaller houses were twenty feet by thirty feet; the potlatch house was fifty feet by two hundred feet. In camping, mats were carried to form temporary shelters. Their marriage regulations differed according to the social standing of the individual. People of high rank married outside the tribe; but such a marriage was only possible to families of considerable wealth; and although marriage with a relative was avoided, union with a cousin might be necessary in order not to mate with a person of lower rank. Poor people who could not marry outside the village or tribe because of the expense of the feasts involved made the best arrangements they could, avoiding parallel and cross-cousin marriages. Marriages with the northern tribes were the most desired. Most of the people are now Shakers, and it is difficult to obtain any complete account of the old religion, but, as in most of the American tribes, the secret society and the guardian spirit were prominent, while there was little idea of superior deities whom every one worshipped.

THE DISPOSAL OF THE DEAD AT WAKCHING, ASSAM.—Mr. J. H. Hutton has obtained details with photographs of a remarkable method of disposing of the dead at Wakching, a village of the Konyak tribe in the Naga Hills, which are published in *Man* for April. After death, the body is wrapped in leaves of the thatching palm and placed in one of a number of trees, usually six, associated with and usually near the *morungs* of the clan using them. Outside the village a rail is put up, with a screen, in front of which is a wooden figure of a man serving as the temporary habitation of the soul. This figure, which ends just below the waist, can be and is used for other dead afterwards. After nine days the head is detached from the body and cleaned by the children or relatives and placed in the village cemetery in a special stone receptacle. This is a solid conical sandstone block from two to three feet in height, with an arched recess to take the skull. The recess is closed with a flat stone and the whole covered with a conical sheath of thatching palm leaf. The skulls of males and females are treated in the same way, but the receptacle for females differs in shape. The fact that persons desirous of having children perform ceremonies over the stones confirms the view that they have a phallic significance. Many of the stones are ornamented with various carved patterns. Persons who die a violent death, or from an epidemic, and children, are not treated in this way. The custom of disposing of the skulls of the dead in phalli of carved stone is apparently limited to Wakching and the neighbouring hostile village of Wanching. It forms a definite link between the menhir and the carved wooden soul figure and with related customs, another link between Assam and the Pacific.

HYBRID VIGOUR IN GRASS.—The results of cross- and self-fertilisation in the grass *Lolium perenne* are reported in a paper by Mr. T. J. Jenkin (*Jour. of Genetics*, vol. 17, No. 1) from the Welsh Plant Breeding Station at Aberystwyth, where much work with grasses for pasturage is being done. Some plants were found to be highly self-sterile, and cross-pollination resulted in some cases in an increase in productivity of more than 200 per cent. It appears, therefore, that seed should be used from crosses which give the greatest F_1 hybrid vigour. Two methods of cutting were also compared, in one of which the early cuttings were omitted. The latter method gave higher yields in every case, but in some F_1 families the difference was much greater than in others. Hence it would probably be possible to select certain plants which are more suitable for grazing purposes and others which are better for hay production.

INHERITANCE OF RUBBER YIELD.—The relationship of latex yield to various other features of the rubber tree, *Hevea brasiliensis*, has been studied statistically by Mr. R. A. Taylor (Bull. No. 77, Dept. of Agriculture, Ceylon). A plot of 161 trees was studied, all the trees being the progeny of a single tree at Peradeniya which is believed to be one of those sent out as a seedling from Kew in 1876. This tree had a very heavy yield, producing nearly 400 lb. of dry rubber in four years nine months. The pollen parent of these 161 trees was not controlled, but the coefficient of variation in their yield is much lower than in trees of mixed parentage. Correlation tables show a high correlation between yield in successive years. Frequency polygons show that a large number of the trees yield the mean amount or a little less, while very few show the high yields. The yield does not depend entirely on the number of rows of latex vessels. The number of rows in the cortex is characteristic of each tree, but some trees with a relatively low number have higher yielding power than other trees with nearly twice as many cortical latex vessels. In cortex renewed after tapping, the number of vessels remains about the same. A count of the vessels gives a better measure of the yield in older trees than in very young ones.

LIME ON THE FARM.—The Ministry of Agriculture has issued a revised edition of Leaflet No. 170, on the use of lime in agriculture. The practice of liming or chalking, though one of the oldest in British agriculture, has tended to be neglected during the last half-century, and the farms of to-day are suffering in consequence. The functions of lime are so numerous that it can be regarded as an all-round soil improver. Besides being an essential plant food, its presence is necessary to render artificial manures effective, and further, it acts as a corrective for soil sourness or acidity and greatly improves the working properties of heavy soil. Regular applications of lime are recommended, as a number of factors cause its depletion in the soil, and although crops vary as to their dependence on the lime supply, a well-limed soil yields more trust-

worthy results during critical periods of the season's growth. A need for lime may be indicated by the prevalence of certain weeds, *e.g.* spurrey, or plant diseases, *e.g.* finger-and-toe. A large number of the different forms of lime available are given, and their comparative values indicated, together with information as to the special points to be observed in the use of each form, and caution is advised as to the application of some waste lime products or lime rich in magnesia. The most suitable material to supply depends largely on the cost, but carbonate of lime can give as good results as burnt lime provided it is sufficiently fine and well distributed in equivalent quantity. Further, ground limestone and chalk have the additional advantage over lime in not deteriorating on storage, and in their harmlessness if applied to a growing crop. The time and method of application should be chosen with the view of ensuring the most perfect distribution. The quantity necessary to apply varies widely with the form of lime applied, but an average dressing of 10 cwt. to 1 ton per acre of ground lime, or 1 to 2 tons per acre of carbonate of lime once in four or five years is suggested.

THE GENUS CLEMENTIA IN AMERICAN TERTIARIES.—Apart from its value as a zone fossil in American Tertiary deposits, the chief interest of the genus Clementia (fam. Veneridæ) lies in the anomalous features of its present and former distribution. Mr. W. P. Woodring now seeks to trace its geological history, its palæobiological significance, and to describe all the known American species (U.S. Geol. Survey, Professional Paper 147—C). Eight forms, species and subspecies, with two doubtful species, are described and figured on four excellent plates. There is also a text map of the world marked to show the present range and past distribution of the genus.

THE MOLLUSCAN GENUS GISORTIA.—When last year (NATURE, vol. 117, p. 246) we recorded a posthumous paper by the late Dr. Vredenburg (died 1923) on the post-Eocene Mollusca of the Tertiary formations of north-west India, no further contribution from his able pen was anticipated. Now, however, a belated monograph by him on the cowry-like genus Gisortia has been published (*Mem. Geol. Surv. India: Palæont. Indica*, New Series, vol. 7, mem. 3). The generic name dates only from 1884, but so far back as 1825 one fossil and one recent representative were described. The latter, the Australian *Cyprœa umbilicata* of Sowerby, remains the unique living example; but Dr. Vredenburg has described thirty-six species in all, going back in time to the Cretaceous period, many only known in the condition of internal casts. All are figured of the natural size on thirty-one photo-plates, and tables given of their stratigraphical distribution and probable zoological affinities. Judging from internal evidence, this monograph would appear to have been completed about 1917.

EARTHQUAKE PREDICTION IN CALIFORNIA.—The question of earthquake prediction is receiving renewed attention in the United States. After the San Francisco earthquake of 1906, two rows of four pillars each were erected across the San Andreas rift, along which the great movement occurred. Dr. J. P. Buwalda now proposes to extend the series so as to cover southern California, and the work is to be carried out under his guidance by the California Institute of Technology, in co-operation with the Carnegie Institution of Washington (*Daily Science News Bulletin*, Washington, No. 313 B). The monuments will be erected in straight lines across suspected earthquake-faults. If, after five or ten years, the lines remain straight, it will be concluded that no great earthquake is in prospect there; but if the line should be distorted into the S-form, the situation will then be regarded as dangerous.

TIDES AND CURRENTS IN ALASKA.—The United States Coast and Geodetic Survey has issued the fourth volume in a series of publications on tidal and current observations made in the more important waterways in United States territory. Special publication No. 127 deals with south-east Alaska and is the work of Lieut. R. W. Woodworth and F. J. Haight. Tidal stations of some standing are now sufficiently numerous on this coast to permit of the discussion of tides for the main ship channels and principal parts. Unfortunately, there are as yet no stations in Glacier Bay, to the east of Lynn Channel, where the Alaskan glaciers that reach the sea must have a disturbing effect on the tides. Current observations, though of comparatively short duration, show a general north-westerly set in the waterways of south-eastern Alaska. The authors attribute this inshore current to a back eddy of the westerly drift across the north Pacific. The larger part turns south-east along the coast of North America, but a smaller part turns north and is driven into the inland passages by the prevailing westerly winds. The volume contains a useful appendix, reprinted from an earlier publication, on the general characteristics of tides and currents.

PEDESTAL ROCKS FORMED BY EROSION.—An interesting contribution to physical geology is made by Kirk Bryan in Bull. 790 A of the U.S. Geological Survey, where he deals with pedestal rocks formed in arid climates by differential weathering. It is shown that many other processes are operative besides wind abrasion, and examples attributed to chemical weathering, temperature changes, differential rainwash and sapping are described. Such processes are also operative in humid regions, but the life of the pedestals there developed is relatively short because of the rapidity of rock decay, and in the colder regions also because of the increased effectiveness of frost action. Moreover, in humid regions the formation of soil and the prevalence of vegetation inhibits the growth of pedestals except when the conditions are especially favourable, as for example when glacial erratics of insoluble rocks rest on a limestone platform.

TWO SHALLOW OILFIELDS IN TEXAS.—On Mar. 8 Dr. Arthur Wade read a paper before the Institution of Petroleum Technologists on the Sipe Springs and Deep Creek oilfields of Texas, both developed in what is technically known as the South Mid-Continent region. In the case of Sipe Springs the area is essentially an inlier of Pennsylvanian (Canyon member) rocks surrounded by Cretaceous deposits, the relationship between the two formations being that of unconformability and overlap. The structure of the field is simple, the beds dipping west at an almost inperceptible angle, with indication of a terrace running from north to south; in this the field resembles many other South Mid-Continent oilfield structures, where often the appreciation of dip is only obtainable by levelling over a wide area. Oil is produced at Sipe Springs from two sands, one at 180 ft. to 200 ft. below the surface, the other 260 ft. to 300 ft.; the former sand is lenticular and production from it is erratic; the latter is a more persistent horizon and is productive throughout the field. In common with other fields in this region, the origin of the oil is doubtful: it may either be indigenous to one of the members of the Pennsylvanian, or it may have originated in the underlying Bend group (Mississippian) from which extensive migration is known to have

occurred. In the Deep Creek field the critical formation is that of the Putnam group, mainly clays with lenticular sandstones, shale, and limestone of rather uncertain age, lying between the Cisco member of the Pennsylvanian and deposits known to be of Permian age. The sandstones contain oil and gas, also salt water. The structure is not unlike that of Sipe Springs, but the westerly dip is slightly steeper. The Sipe Springs oil is of good quality with an average gravity of 0·83; that of the Deep Creek field is similar; in fact, considering that the oil of these fields is derived from distinctly different formations, the similarity of physical and chemical properties in both cases is remarkable.

LARGE VACUUM TUBE.—What is stated to be the world's largest vacuum tube, constructed by the General Electric Co. of America, has now been in use in a radio station for several weeks. It is seven and a half feet high and weighs 100 lb. It is rated at 100 kilowatts, and is kept cool by a copper jacket through which water is kept circulating. It takes the place of eight 20-kilowatt tubes, which were formerly used. Hitherto 50 kilowatts has been the maximum power given to the antenna of a 'super-power' radio station. A battery of the new tubes will permit experiments with 500 kilowatts in the antenna. This is one thousand times the power used by a typical broadcasting station three or four years ago. Two ounces of tungsten are used in the filament, which is as thick as the lead in a lead pencil, and is eight feet long.

DENSITY OF THE PHOTOGRAPHIC IMAGE.—In two papers in the *Proceedings of the Royal Society of Edinburgh* (vol. 45, pt. 2, p. 166; 47, pt. 1, p. 34) Dr. E. A. Baker describes in detail the large amount of experimental work carried out by him in connexion with Prof. Sampson's investigations on the temperature of a great number of stars by determining photographically the distribution of energy in their spectra. Dr. Baker's work consists essentially in a rigid calibration of the particular types of photographic plates used by Prof. Sampson, so that the true interpretation in terms of intensity can be given to the densities obtained on the plates when the time of exposure, the conditions of development, and wave-length of the light are varied. The author starts with a perfectly general expression connecting the intensity with the variable factors density, exposure time, and wave-length, and finds it convenient to consider two characteristics of the plates, which he calls p and q, and to determine how they are affected by variation in these factors. p is the so-called Schwarzschild constant and q is analogous to γ, the slope of the characteristic curve, and at higher density values is equal to p/γ. Amongst other interesting results it is found that for a constant blackening and constant exposure time, the variation of p with wave-length is very small, a result which is to be expected if p depends on the value of the effective intensity (*i.e.* the energy absorbed by the plate per second) and if equal effective intensities of different wave-lengths produce densities of the same order. The larger part of the second paper is devoted to a new theory of the relation between the number of grains of silver halide affected, the intensity of the incident light, and the duration of the exposure (see also NATURE, Sept. 11, 1926, p. 374). Without entering here into the details of the theory the conclusion is, to quote Prof. Sampson, "that the initial stages of the photographic action, including the deviations from the reciprocity law, are calculable and well represented by assuming that the developable product is formed in two stages, each stage requiring one quantum, and that the product of the first stage returns in the absence of further stimulus to its original sensitive state, according to the law governing the progress of a mono-molecular change." The idea involves, apparently, two distinct kinds of absorbers of energy in the silver halide grains, one for each stage.

CALCIUM IN ALUMINIUM CONTAINING SILICON.—Mr. J. D. Grogan read a paper at the recent spring meeting of the Institution of Metals on "The Influence of Calcium on Aluminium containing Silicon." The addition of calcium to aluminium results in the formation of a compound, $CaAl_3$, which is very slightly soluble in solid aluminium. By the addition of silicon to this alloy, the compound $CaSi_2$ is formed, which is practically insoluble in the solid state at all temperatures. Neither compound appears appreciably to improve the mechanical properties of aluminium, or to impart age-hardening properties. The addition of suitable quantities of calcium to aluminium containing silicon improves the electrical conductivity by removing silicon from solid solution. As the effect of $CaAl_3$ on the conductivity of aluminium is relatively small, the effect of a slight excess of calcium is not harmful.

MOLYBDENUM IN NICKEL-CHROME STEELS.—Report No. 67 from the Research Department, Woolwich, on "The Influence of Molybdenum on Medium Carbon Steels containing Nickel and Chromium," shows that the addition of molybdenum to nickel-chrome steels raises the AcI point but lowers ArI. In many cases the Ar point is depressed to 470° C.—Ar″—unless the rate of cooling is very slow. Molybdenum has a more powerful effect than nickel or chromium in reducing the liability to imperfect hardening when the rate of cooling is slow, and reduces the softening on tempering. About 0·5 per cent. of molybdenum is sufficient to bring about most of the possible improvement in these steels. The 'mass-effect' is reduced by the presence of the third alloying element, when the mechanical results show great uniformity even in the biggest forgings. Tests can be repeated with great regularity, indicating that the steels are unaffected by slight departures from standard conditions of treatment. The elastic properties, ductility, and impact value are all improved by the addition of molybdenum, which has the further great advantage that it has a pronounced effect in considerably reducing, or completely eliminating, the susceptibility of the steel to 'temper-brittleness.' Nickel-chrome-molybdenum steels provide the best all-round combination of properties, though nickel-molybdenum and chrome-molybdenum steels approach them nearly. When treated so as to give a tensile strength of 50 tons-60 tons per sq. in., the best composition from these three types of steel—in each case with a carbon content of 0·3 per cent.—are as follows: Nickel-chrome-molybdenum: Nickel 2·6 per cent., chromium 0·6-1·1 per cent., molybdenum 0·6-0·4 per cent.; steels in this range of composition all gave very similar properties when tempered to the same hardness, the higher chromium content being an advantage when a tensile strength of 60 tons per sq. in. or more is required. Chromium-molybdenum: Chromium 1·0-1·5 per cent., molybdenum 1·0-0·5 per cent.; slightly inferior in general properties but gives higher notched-bar impact figures. Nickel-molybdenum: Nickel 2·7-4·0 per cent., molybdenum 0·6-0·4 per cent.; rather better in yield ratio than the nickel-chrome-molybdenum steel but inferior in impact value; when the nickel exceeds 3 per cent., as is necessary to obtain a tensile strength of 60 tons per sq. in., these steels show distinctly lower impact values and also become difficult to machine.

The Embrittlement of Boiler Plates.

THAT boiler plates may become brittle in the course of time and in certain circumstances is now a well-established fact. All the conditions, however, which govern the phenomenon are by no means completely known, and the problem raises points both of great practical and of scientific importance. A paper entitled "The Cause and Prevention of Embrittlement of Boiler Plates," by S. W. Parr and F. G. Straub, Bulletin No. 155 of the University of Illinois Engineering Experiment Station, which deals with the subject at some length, is therefore of considerable interest.

It is first shown that of the recorded examples of brittle boiler plates in America, there are certain areas where the trouble is more evident than in others. This at once suggests that the water is the cause of the failures, and this is strengthened by the fact that in these localities the waters used are characterised by an almost complete absence of sodium sulphate and by the presence of free sodium bicarbonate. It is to the latter salt that the authors attribute the primary responsibility for the embrittlement. The type of boiler used is not believed to have any influence, since failure due to brittleness has occurred in a considerable number of different makes and designs, both fire- and water-tube. Further, the writers reach the very interesting conclusion that the steel from which the plates are made has *per se* no effect either. Their reasons for coming to this conclusion are as follows: Six different types of steel which had become brittle in actual boiler service were examined. The carbon content ranged from 0·14 to 0·26 per cent., the manganese from 0·26 to 0·54, the phosphorus was consistently low, and the sulphur varied from 0·018 to 0·046 per cent. Micrographic examination also indicated that good steel was just as liable to fail as low-grade, dirty material. In the experimental work described, steels were investigated in which the range of composition was:

Carbon . . .	0·023-0·30	per cent.
Manganese . . .	0·017-0·45	,, ,,
Sulphur . . .	0·007-0·027	,, ,,
Phosphorus . .	0·003-0·012	,, ,,

Apart from the question of the yield point, variation of the composition of the steel within this range had very little, if any, effect on the rate of embrittlement.

The experimental work on short-time, accelerated tests confirmed what had been previously believed, namely, that stress and the nature of the solution each played essential parts in causing brittleness. So far as the former factor is concerned, it is shown that this must exceed the yield point of the steel before failure commences. There are also indications that, provided this stress intensity is attained, the actual value of the stress is not of prime importance. As, therefore, the yield point of the material is raised, so will also be the stress to which the steel may be subjected in service without failure due to brittleness ensuing. Thus 3·5 per cent. nickel steel showed in the tests no abnormality other than the increased stress required to induce embrittlement. A steel severely cold-worked previous to test also appeared to require a rather higher stress to initiate the trouble than the same steel in the annealed condition. In connexion with the latter factor the temperature used in the annealing of the steels had very little effect. A fact recorded which is, however, somewhat difficult to reconcile with the foregoing is that with high sulphur and phosphorus contents the steel is more liable to become brittle; for example, a decided increase in the rate of embrittlement is recorded for a material with 0·215 per cent. of sulphur and 0·126 per cent. of phosphorus compared with normal steel. The explanation offered for this effect of these elements is not convincing.

The examination of the surface of embrittled plates shows no corrosion, but there is, as in all cases, a layer of magnetic oxide of iron. So long as this is compact and complete, further attack on the metal is inhibited, but if for any reason the coating is broken, the unprotected metal surface is then again laid open to chemical attack from the solution. The importance of the yield-point stress is thus apparent. Under this stress there will be sufficient plastic deformation of the metal to fracture the oxide film and the attack will recommence.

So far, then, as the prevention of this embrittlement is concerned, one of the methods by which this could be done would be by cutting down the actual stress to a value below the yield point. This the authors regard, however, as being impractical. The failure is associated with the seams where the different plates are riveted together, the cracks produced running in general from one rivet hole to another and not extending into the body of the plates beyond the lap of the seam. Now, both in the operation of riveting and under the conditions of service, greatly concentrated, localised stresses must occur in such positions, and stresses exist there considerably exceeding the yield point even when the steel plate as a whole is far below its yield stress.

It follows, therefore, that the only effective protection will come from the consideration of the water used. As has already been mentioned, the characteristics of those natural waters which in the United States have led to this type of failure are the presence of sodium bicarbonate and a low concentration of the sulphate. In time, then, a caustic condition will be set up in the boiler with the sodium hydroxide in excess of sodium sulphate, and it is to this caustic soda directly that the embrittlement is ascribed. The reaction assumed to be responsible is represented by the equation

$$3Fe + 4OH' = Fe_3O_4 + 4H^{\cdot}.$$

The hydrogen then passes into solid solution in the steel and leads to brittleness. This attack is shown to be a surface phenomenon by measurement of the e.m.f. of the original and brittle steel against caustic soda solutions and by the grinding off of the affected surface, when the e.m.f. value becomes again that of the untreated steel. In accelerated tests it was shown that a concentration of 350 gm. of caustic soda per litre is required to initiate the failure. This value, it is supposed, may in time be reached between the plates where they overlap, but it is also realised that such figures from accelerated tests need not necessarily apply to conditions in service, and that under prolonged application of stress even lower concentrations may be equally important.

Passing on to consider the treatments of the water which are possible and would lead to inhibition, the authors' view is that neutralising the alkalinity of the water with sulphuric acid could not be carried sufficiently far without endangering the boiler. It was found, however, that increasing the concentration of sodium sulphate or carbonate in relation to that of the hydroxide retarded and eventually prevented the attack. This effect has been studied for several years on an actual boiler, in which the feed-water was maintained with a ratio of sulphate to carbonate of 2 by neutralising about 70 per cent. of the alkalinity

with sulphuric acid. After ten years of operation the boiler is in perfect condition, whereas a similar plant using, apart from the water treatment, identical conditions, was condemned after nine years.

It is clear, however, that the treatment must be done under expert supervision. The same applies equally to the addition of aluminium or magnesium sulphate. This treatment is very effective when used in connexion with settling tanks and filters which remove the possibility of scale-forming ingredients entering the boiler, but if used in excess, the salts are distinctly harmful and the quantities added need careful control. Undecomposed sodium carbonate acts as an inhibitant, and cases are on record where the sulphate-carbonate ratio of the water was exceedingly low without any indications of brittleness due to high sodium carbonate content. It is, however, well to regard the carbonate as the potential source of the hydroxide. The authors finally consider that the best ratio to adopt as standard in water treatment for boilers is that of the combined sodium sulphate and carbonate to the hydroxide. Although they are not yet prepared to suggest hard and fast figures, they believe that when this ratio exceeds 2, it is sufficient to stop the embrittlement. F. C. T.

Whales and Dolphins.[1]

THE scientific heads of the British Museum for many years (just as Dr. R. Knox, Prof. Goodsir, and Principal Sir William Turner did in the northern capital) have devoted much attention to the cetaceans, as seen in Dr. Gray's Catalogue, Sir R. Owen's *Kogia*, and the important publications of Sir William Flower—to whom the public owe the interesting Whale Gallery at the Natural History Museum, South Kensington, with drawings from life by his daughter. It was, however, reserved to the director who has just retired, Sir Sidney Harmer, to systematise the means for obtaining information of all the species—of this most intelligent and interesting as well as much persecuted group—caught or stranded on British shores. In the publication before us he has further added to the indebtedness of the public and men of science by summarising the results of his labours, which, by aid of the officials of the Board of Trade and others, have largely extended our information.

In few groups are there more striking examples of maternal solicitude than in the Right whale, or more conspicuous social instincts than in the Pilot whale. Such is proved by the cruel methods of the old whalers in harpooning the helpless young in order to secure the anxious mother, whilst in the latter group a single example will suffice—thus when more than two hundred were embayed with their leader, an old male, in Scalloway harbour (a kind of pocket with a narrow entrance), the leader dashed through both the inner and the outer cordons of boats and reached the open sea, but when he found he was alone he turned shorewards, again rushed past both lines of boats, and was killed in the midst of his followers in Scalloway harbour, where to this day their skulls make suitable wedges to support the boats.

The first part of Sir Sidney's memoir gives practical information as to measurements of specimens, the different kinds of Cetacea and their sex-characters, illustrated by excellent figures. A brief account of toothed and whalebone whales follows. As an appendix to the list of porpoises, the fact is recorded that in summer in Shetland no less than 100 to 150 may occasionally be seen disporting themselves close inshore in Bressay Sound—probably attracted by a shoal of fishes. The female porpoise gives birth to her young often in June, and she may be watched swimming in circles close inshore with it, or resting on her side with a flipper in the air as it suckles. To Sir Sidney's remarks on the various forms it may be added that some of the larger dolphins occasionally 'breach' like the Humpback whale from the side of a huge wave, again noisily striking the water. The Killer, besides occurring on the east coast, may often be seen in the Sound of Raasay, not far from Portree in Skye, the long dorsal fin projecting above water, steadily propelled as if from a powerful screw.

The author makes important remarks on Cuvier's whale, formerly thought to be rare, especially in connexion with the prenarial basin of the male, about which he hazards the reasonable view that it "is occupied by derivatives of the two narial passages, perhaps diverticula which lie in the basin and are separated ventrally by the reduced prenarial part of the mesorostral." He also discusses skin-markings of whales, with remarks on age and disease, and the sizes of the newly born—quoting from Mr. R. C. Haldane's paper of 1905 (*Ann. Scottish Nat. Hist.*, No. 54) the fact that the young Finner when born is about 20 feet long, and that "sucking calves of 40 feet have been seen."

Tables follow with the Cetacea stranded in 1925 and 1926—27 in the former and 47 in the latter year. In his brief remarks on some of these the author observes that a white-sided dolphin caught in the beginning of August in the Loch of Stenness (near Stromness) at a time when Salps in large numbers pass from the Atlantic to the North Sea may have been attracted by them. Unfortunately, the contents of the stomach were not reported. This view would interest some in connexion with the Fishery Board for Scotland, who took the view that the hordes of Salps ousted the herrings from their usual haunts, the fact being that herrings and other fishes (if not whales) have, like birds and many invertebrates, a relish for Salps or part of them.

Under the tenth head a summary of the characters of the British toothed and whalebone whales, and a key for determining species, are given—a useful guide for all who come in contact with them, especially in such cases as True's Beaked whale, which has only occurred twice on the coasts of Britain.

Appended to the report are seven very useful quarto maps of the British Isles, the first indicating the stations where all the Cetacea during 1925 and 1926 were obtained, the field being generally dotted—with perhaps a denser grouping in the north. The second map is devoted to the common Dolphin, with maximum stations for 1913–1926 to the south and west, the latter areas also being in the ascendant for the Bottle-nosed and the White-beaked Dolphins. The other maps for the Killer, Hyperoodon, Cuvier's, Sowerby's, and True's Beaked whales, as well as the whalebone and spermaceti whales, are equally instructive for the period.

In dealing with the scientific names of the various species, the author throughout has unfortunately refrained from adding the name of the authority for each, probably to avoid complication.

The publication of this report will do much to facilitate the recognition of cetaceans by the public as well as to afford useful information to men of

[1] Report on Cetacea stranded on the British Coasts from 1913 to 1926. (No. 10.) By Sir Sidney F. Harmer. Pp. 91+7 maps. (London: British Museum (Natural History), 1927.) 7s. 6d.

science, and Sir Sidney Harmer is to be congratulated on his statistical and other labours, and the completion of so important a summary. It is to be hoped that his methods will be continued by the Museum on similar lines in future. Both in this respect and in his influence and exertions in connexion with the arrangements for the expedition in the *Discovery* and *William Scoresby* to the Falkland Islands in search of further knowledge of the life-history of the cetaceans, science and the public are deeply indebted to him. W. C. M.

University and Educational Intelligence.

ABERYSTWYTH.—Prof. H. Stuart-Jones, Camden professor of ancient history in the University of Oxford, has been appointed Principal of the University College of Wales.

LONDON.—Three public lectures on "Some Surgical Problems" will be given at the Middlesex Hospital Medical School at 5 o'clock, on May 16, 17, and 18, by Prof. J. Fraser. A course of four public lectures on "Inflammation and Infection" will be given at Guy's Hospital Medical School at 5.30, on May 20, 27, and 31, and June 3, by Prof. E. H. Kettle. No tickets will be required.

MANCHESTER.—Applications are invited from persons born in or inhabitants of the County of Lancaster, preferably the County Borough of Rochdale, for the Sir Clement Royds memorial scholarship in chemistry in the University of Manchester, the value of which is £300. The applications should be sent by, at latest, June 1 to the Registrar.

OXFORD.—A public lecture will be given by the Right Hon. Sir John Simon, M.P., on Saturday, May 7, at 12 noon, on "The Labrador Boundary."

The Romanes Lecture for 1927 will be delivered by Sir Frederic George Kenyon, Director and Principal Librarian of the British Museum, at the Sheldonian Theatre on Friday, June 17, at 5 P.M., on the subject of "Museums and National Life."

ST. ANDREWS.—The Senatus Academicus has resolved to confer the honorary degree of LL.D. upon Sir Richard Gregory and upon the Right Hon. Sir Alfred Mond, P.C., M.P., at the graduation ceremonial to be held on June 28.

Mr. G. J. Robertson has been appointed to the senior lectureship in the Chemistry Department of the United College of St. Salvator and St. Leonard, in succession to Dr. G. McOwan.

THE Salters' Institute of Industrial Chemistry is inviting applications, until June 1, for a limited number of fellowships, each of the normal value of from £250 to £300, from chemists of post-graduate standing who are desirous of adopting a career in industrial chemistry; also, until June 10, for a limited number of grants-in-aid to young men and women employed in chemical works in or near London who desire to extend their education for a career in chemical industry. The applications should be sent to the Director of the Institute, Salters' Hall, St. Swithin's Lane, E.C.4.

THE London School of Economics is making arrangements for a series of lectures and discussion classes on the ethnography of Africa. During the summer term Prof. C. G. Seligman will give a course of lectures on "The Nile Valley and its Peoples." In the Michaelmas term of the session 1927–28, Mr. J. H. Driberg will give a course on "The Ethnography of East-Central Africa," and will deal with the ethnography of West Africa and also with the reactions of primitive African cultures to economic development in the following lent and summer terms, whilst arrangements will also be made for Mr. I. Schapera to give a course on the ethnography of South Africa. Further details of this and other lectures on ethnology can be obtained on application to the Secretary of the School.

UNIVERSITY COLLEGE, London, celebrates this year the hundredth anniversary of its foundation. On April 30, 1827, the Duke of Sussex laid the foundation-stone of what was in the first instance styled the University of London but was incorporated by Royal Charter in 1836 under the name of University College, London. Another separate body was chartered on the same day as the University of London, with power to grant degrees in arts, laws, and medicine, after examination, to candidates who should present certificates of having completed the requisite courses at University College and such other institutions as might be approved for the purpose. To-day, with more than three thousand students, including five hundred post-graduate and research students, and its graduation list of nearly three hundred, it has an importance not less than that of many full-fledged universities. Attracting students from many countries both within and outside the British Empire, it has a cosmopolitan character and makes its influence felt throughout the world. It is marking the completion of its first hundred years by a campaign for raising half a million sterling towards building and equipment and better endowment.

IN the Report of the Imperial College of Tropical Agriculture, Trinidad, 1925–26, the Principal, Dr. H. Martin Leake, gives an account of the lines upon which the College is developing. The completion and occupation of the new buildings is an outstanding feature of the past year; but owing to the increasing number of students, further accommodation is already required. A residential hostel is in course of construction but is not yet completed. The field from which students are drawn is widening; in the past year four came from the Union of South Africa and one each from Brazil, Egypt, and Ecuador respectively, in addition to those from the West Indies and Britain. At the same time students who have passed through the College are becoming widely distributed throughout the British Empire. The shortage of staff has again seriously restricted the output of research work, but the issue of the Fruit Report drawn up by the Imperial Economic Committee is an important feature. A large section of the work has been devoted to the subject of bananas, the question of greatest importance being to secure a variety immune from Panama disease and also of satisfactory carrying capacity. The Giant Fig fulfils the first of these requirements, but much further work is necessary before the optimum conditions for shipment can be determined. The serious problem of the froghopper pest of sugar-cane has also been actively investigated. The degree of attack is to a great extent dependent on the physiological condition of the plant, so that much fundamental work has to be done before the intimate relation between host and parasite can be elucidated. Such studies, however, will probably have an important influence on allied problems. Tobacco investigations have been extended, but the inadequacy of curing facilities has proved a hindrance.

Calendar of Discovery and Invention.

May 8, 1654.—One of the most striking demonstrations in physical science made during the seventeenth century was that of Otto von Guericke, who on May 8, 1654, before the assembled princes at Ratisbon, showed his great experiment with the big Magdeburg hemispheres which, when exhausted of air, could not be pulled asunder by sixteen horses.

May 8, 1795.—Though the planet Neptune was not discovered until 1846, yet it was shown as a star in Harding's Atlas of 1822, and on May 8 and 10, 1795, Lalande had also registered it as a star.

May 9, 1865.—The first application of hydraulic power to machinery was due to Lord Armstrong; but its application to machine tools was due to Tweddell who, on May 9, 1865, patented a hydraulic riveter for fixing the ends of boiler tubes. In the same year he also designed hydraulic riveting plant for a Newcastle firm, enabling machine riveting to be carried out at one-seventh of the cost of hand riveting.

May 10, 1752.—Dalibard, the French botanist, was the first to draw electricity from a thundercloud. By means of an insulated rod forty feet long fixed in a stand, on May 10, 1752, when a thundercloud was overhead, sparks were drawn from the rod, leading Dalibard to write, "Franklin's idea ceases to be a conjecture. Here it has become a reality."

May 11, 1671.—On this day Nehemiah Grew's "Anatomy of Plants begun" was read before the Royal Society and ordered to be printed. It was published the following year, and later was translated into Latin, French, and Italian. In 1682 it was incorporated in the author's larger work, "Anatomy of Plants." With Malpighi, Grew shares the honour of the foundation of plant anatomy.

May 12, 1881.—In the Berlin Exhibition of 1879 an electric railway, one-third of a mile long, was shown in operation, and similar demonstration lines were installed in other exhibitions. The first permanent electric railway was that from Berlin to Lichtenfelde, which was put into operation on May 12, 1881. Electricity at 100 volts was utilised, one rail being positive and the other negative.

May 13, 1731.—After spending some years in effecting improvements in reflecting telescopes, which led to their wide adoption, John Hadley turned his attention to instruments for measuring angles, and on May 13, 1731, read to the Royal Society a paper entitled "Description of an Instrument for taking Angles." By the introduction of the use of two mirrors, Hadley was for the first time able easily to measure angles subtended by distant objects, independently of small changes in the position of the observer.

May 14, 1796.—Jenner's famous experiment in inoculation was made 131 years ago. He had long desired to try the passing of the vaccine virus from a human being to another by the ordinary mode of inoculation, and on May 14, 1796, a boy named Phipps was inoculated in the arm from a pustule on the hand of a dairymaid, Sarah Nelmes, who was infected by her master's cows. Writing a little later, Jenner said, "But now listen to the most delightful part of my story. The boy has since been inoculated for the smallpox which, as I ventured to predict, produced no effect."

May 15, 1836.—It was during the annular eclipse of the sun of May 15, 1836, that Francis Baily saw the phenomena called "Baily's Beads," of which he gave a very striking description. Though in later eclipses the "Beads" were not so vividly seen, Baily's account did much to stimulate attention to the physical aspects of solar eclipses. E. C. S.

Societies and Academies.

LONDON.

Royal Meteorological Society, Mar. 20.—R. A. Watson Watt: The range of atmospherics (Report of the Committee on Atmospherics and Weather). The distances over which an atmospheric may produce disturbance of broadcast reception was discussed. The Committee organised experiments in which observers in the British Isles, Norway, Germany, France, Spain, Morocco, and Madeira recorded disturbance of broadcast talks, while the sources of the atmospherics were identified by radio position-finding by the organisation set up by the Department of Scientific and Industrial Research on the advice of its Radio Research Board. Many of the sources were found to lie in regions of meteorological disturbance. Atmospherics from beyond the Azores have disturbed the reception of Daventry's signals in Paris and of London's signals in Aberdeen, and a thunderstorm at Rome disturbed reception in Spain, France, Madeira, the British Isles, and Norway. Many atmospherics are heard at distances exceeding 1800 miles from their sources, and may reach at least 4500 miles. There is no evidence of the presence of many atmospherics with a short range of disturbing effect.

Geological Society, April 6.—Vincent G. Glenday and John Parkinson: The Kateruk series and associated rocks of the northern Suk Hills (Kenya Colony). A series is described of completely metamorphosed sediments which crop out on or near the Kateruk River, an eastward-flowing tributary of the Turkwal River, situated about 30° 15′ long. E. and 2° 37′ lat. N., in the north-western part of Kenya Colony. The rocks consist of the metamorphosed representatives of various sedimentary deposits, ashes being included. The constituents indicate a somewhat lower grade of metamorphism than those of the Turoka series of the south, and may prove to be slightly younger.—H. L. Hawkins and Miss S. M. Hampton: The occurrence, morphology, and affinities of the Silurian Echinoidea Echinocystis and Palæodiscus. Church Hill Quarry, near Leintwardine, was re-opened, and a careful record of the sediments was made. A column of rock was excavated to a depth of 12 feet 6 inches from the surface. The beds traversed are all calcareous flaggy mudstones, varying slightly in lime-content. Ripple-marked surfaces were found at two horizons. Fossils are very rare, except in congested bands. The series seems to have accumulated in shallow lagoon-water, and the indigenous fauna of echinoderms and Lingulæ was periodically reinforced by brachiopods, pteropods, and graptolites drifted in during storms. New material of Echinocystis and Palæodiscus, including specimens which show obverse and reverse casts, and others showing upper and under surfaces of the test, has made it possible to solve many of the problems associated with the genera. Echinocystis is revealed as a typical perischœchinoid, with a normal endocyclic apical system and an advanced complexity of ambulacral structure. In Palæodiscus, the indications of an endocyclic apical system seem convincing. The reputed 'Asteroid' ambulacral plates are knob-like ingrowths from the perradial zones of the otherwise normal plates. Both genera are claimed as advanced perischœchinoids—far too specialised to show pre-echinoid features.

Society of Public Analysts, April 6.—C. Ainsworth Mitchell and T. J. Ward: The sequence of strokes in writing. Systematic experiments have been made to determine to what extent one may trust to the appearance of one of two intersecting lines being

uppermost as a proof that it was made more recently than the other. The appearance coincides with the fact in the case of insoluble opaque pigments such as lead pencil, but is deceptive with a transparent pigment such as an aniline dye. The relative position of lines made with writing inks which undergo oxidation, and thus form an opaque insoluble pigment, can usually be accurately determined, but if the ink has been blotted the observation is, as a rule, untrustworthy.—D. W. Kent-Jones and C. W. Herd: (1) Observations on the washing of gluten from flour. The use of a special washing solution does not eliminate the errors inherent in gluten determinations. Even when the same amount of washing water is used and the same procedure followed, personal differences in the manipulation of the dough and gluten cause large variations in the result. Each operator, however, gets essentially consistent results, which means that the ratio between the nitrogen of the flour and the dried gluten is approximately constant for each worker. (2) A numerical expression for the colour of flour. The yellow colouring matter is extracted by means of petroleum spirit, and its colour measured in a special form of colorimeter. This figure indicates the natural whiteness, or alternatively, the artificial bleaching of the flour. The grade of the flour may be judged by the amount of the reddish-brown pigment present which, presumably, comes from the finely powdered offal. This pigment is determined in the colorimeter after extraction with alkaline methyl alcohol.—H. B. Dunnicliff and Kishen Lal: The determination of free mercury in commercial products. The main constituents of the substance containing free mercury are removed by extraction with a suitable solvent. The residue is treated with bromine water, the resulting mercuric bromide is dissolved in alcohol, and the mercury is precipitated as mercuric sulphide, which is filtered off and weighed in a Gooch crucible.

PARIS.

Academy of Sciences, Mar. 28.—G. Friedel: The recent controversy between MM. Hettich and Valeton. Holoaxial hemihedral forms do not necessarily imply the hemihedry of the crystal.—Norbert Wiener: A new method for the demonstration of Tauber's theorems.—Julius Wolff: A generalisation of a theorem of H. Jentzsch. — Sugot: The gyroscopic movement of the projectile near the mouth [of the gun].—R. Mazet: The flow of a liquid starting from rest in a liquid of the same density in steady motion.—Huguenard, Magnan, and V. Sainte-Laguë: The kinematographic determination of the polars in the flight of birds, gliders, and aeroplanes.—E. Carafoli: The movement round a plane plate in rotation.—Louis Breguet: Long flights without stops and the distance record in an aeroplane. — Rateau: Observations on the preceding note.—Th. De Donder: The physical interpretation of the equation of quantification of continuous systems.—Jean Jacques Trillat: The analytical interpretation of the X-ray spectra of the fatty acids and their mixtures. The same spectrum is always obtained from a pure or nearly pure acid if the preparation is made by fusion on a glass plate or by evaporation from an alcoholic solution. With mixtures of fatty acids the position of the lines cannot be predicted from the known proportions of the constituents. The study of a mixture of fatty acids fused on glass does not give the qualitative composition of the mixture, but more definite results are obtained when lead is substituted for glass.—A. Boutaric and Mlle. G. Perreau: The possibility of modifying at will the electrical sign of colloids.—Maurice Lecat: Formulæ for predicting the azeotropic constants of systems formed of an alcohol and an alkyl halide.—René Girard: The action of complex saline solutions on the ferrous metals. With a mixture of salts in solutions, such as an artificial sea water, the net result depends on the texture of the corrosion products.—Marcel Godchot: Some syntheses of glycols containing the ether oxide grouping. —André Kling and Daniel Florentin: The hydrogenation of naphthalene and of anthracene at a high temperature and under high pressure in the presence of non-hydrogenating catalysts. Results of experiments are tabulated shewing effects, on yields and nature of hydrocarbons produced, of varying pressures of hydrogen, and also the effect of adding a catalyst.—Barré: A new method of preparing α-ketonic acids. The interaction of ethyl magnesium bromide on ethyl diethyloxamate, $C_2H_5 . O . CO . CO . N(C_2H_5)_2$, gives rise to two products, the diethylamide of α-ethyl-α-oxybutyric acid $(C_2H_5)_2 C(OH) . CO . N(C_2H_5)_2$, and the diethylamide of propionyl formic acid, $C_2H_5 . CO . CO . N(C_2H_5)_2$, and the reaction can be modified to give either of these as the principal product by varying the temperature and the proportion of the magnesium compound. Propionyl formic acid can be obtained with good yields by hydrolysis of its diethylamide, and this method for the preparation of α-ketonic acids is more advantageous than those hitherto in use.—A. Wahl and Féricéan: Disulphisatide. Experiments are given proving that the double formula, $C_{16}H_{12} . O_2 . N_2S_2$, is more probable than the single formula, $C_8H_7 . ONS$ suggested by Sander.—J. Campardou: The general preparation of hydrocarbons by the reduction of organic substances. The use of carbon and carbon monoxide. A description of a general method of reduction based on the action of carbon monoxide at 400°-450° C., in the presence of wood charcoal as a catalyst.—A. Demay: The mylonitic zone of Grimaud and the prestephanian breaking away of the western part of the Maures massif.—Georges Mouret: The geological constitution of the Arnac-la-Poste region (Haute-Vienne).—H. Colin: The formation of sugar in the beet.—R. G. Werner: Compulsory symbiosis or independent life of the fungi of lichens.—Jacques Rollet: Histological researches on testicular grafts in mammals (white rat). The observations cited show that there is never a true graft.—A. Gurwitsch and Mme. L. Gurwitsch. The secondary mitogenetic radiation.—Ch. Achard, A. Grigaut, and A. Leblanc: The lipoid equilibrium of the blood serum.

ROME.

Royal National Academy of the Lincei, Feb. 6.—G. Armellini: Horizontal diameter of the sun in 1925 and 1926. The results of three observers give for the horizontal radius of the sun at its mean distance from the earth the mean value $16' 0{\cdot}63 \pm 0{\cdot}04''$ for 1925 and $16' 0{\cdot}09 \pm 0{\cdot}04''$ for 1926, the value being $16' 1{\cdot}03 \pm 0{\cdot}04''$ for 1924. These results confirm the gradual diminution in the solar diameter corresponding with the maximum of sun-spots occurring in 1927–1928.—L. Petri: The presence in plants of a substance which becomes luminescent in ultra-violet light. This substance, previously noted, withstands dry heat at 170° C. but is destroyed by incineration of the plant tissues. It occurs most abundantly in those organs capable of effecting the photosynthetic assimilation of carbon and possibly constitutes a factor necessary to such assimilation, although it is not an integral part of the pigments contained in the chloroplasts. It is found in subterranean organs, but only in those which form chlorophyll if exposed to light.—M. Picone: 'Majoration' of the integrals of elliptico-parabolic linear equations with partial derivatives of the second order.—E. Bompiani: The geometry of Laplace's equation.—Arturo Cecconi:

A theorem on the work of elastic deformation.—B. Caldonazzo: An observation concerning viscous motion symmetrical with respect to an axis.—A. Weinstein: The theorem on the existence of liquid jets.—G. Rossi: Observations on the scintillation of the stars at the Royal (Italian) Observatory, Campidoglio. The phenomenon of scintillation oscillates about a mean condition in accordance with laws analogous to those governing so-called casual phenomena.—A. Carrelli: The summation theory of Thomas and Reiche.—G. Piccardi: Order number, excess weight, and atomic structure. Chemico-physical considerations concerning the relations between atomic number and atomic weight, in conjunction with astro-physical considerations, lead to the hypothesis that the excess positive and negative electrons, represented by the difference between the atomic weight of an element and twice its atomic number, are arranged outside of the atomic nucleus. It seems possible to formulate a complete theory of isotopes on this foundation.—G. R. Levi and A. Reina: Peptisation of 'meta' thorium oxide. Investigation of the process of peptisation of thorium oxide by X-ray analysis shows that the 'meta' variety of this compound has a distinctly higher degree of subdivision than the ordinary product, and that this process involves no further subdivision of the separate crystalline granules and no increase of the interatomic distances.—G. Bozza and G. Devoto: Calculation of the chemical affinity on the basis of entropy.—G. Ponte: Temperature of laval percolations from Etna. Consideration of the observations recorded by previous investigators indicates that the temperature in the bed of the flow of a stream of lava is transmitted slowly and may rise considerably in the central part where the movement is greatest, that is, where fresh hot lava is continually arriving. The extent of the cooling at the surface naturally depends on a number of factors.—P. Principi: Miocene strata between the valleys of the Lamone and Bidente.—D. Rosa: A possible variant of hologenesis.—Darwin Wen: New experiments on the hereditary behaviour of the capacity of the egg for development. Parthenogenesis in crosses between uni- and bi-voltine races of *Bombyx mori*.—G. Cotronei: The systematic biology of Petromyzon.—U. D'Ancona: Growth of the Tiber shad. The curve representing the length of this fish in relation to its age resembles a parabola, whereas the weight-age curve is analogous to that representing autocatalytic reactions according to Robertson's equation, $\log x/A - x = K(t - t_1)$. Hence, the value of k in the equation, $P = kL^3$, where P is the weight and L the length, varies with the age. The growth in length varies during different months of the year in a manner represented approximately by a sinoidal curve, which is superposed on the parabola showing the annual growth. The growth in weight also exhibits oscillations with an annual period, the amplitude being small before the attainment of sexual maturity, and considerable afterwards.

VIENNA.

Academy of Sciences, Mar. 10.—H. Mache: Nernst's heat theorem and the impossibility of attaining absolute zero.—A. Kieslinger: (iii) The stone-ovens (*Steinöfen*) of the Kor Alp region; (iv) Old and young disintegrations in the Kor Alp region.—H. Herrmann: The behaviour of frog's lymph towards blood of another species.—J. Pollak, K. Deutscher, and M. Krauss: The course of Leuckart's xanthogenate reaction.—E. Blumenstock-Halward: The action of aqua regia on fluorine.—O. Lustig and E. Katscher: The action of chlorosulphonic acid on aromatic amines.—J. Warkany: (i) The problem of the destruction of lactic acid by erythrocytes; (ii) The methods of determining lactic acid in urine.—J. Lense: A contribution to the geometry of the sphere.

Mar. 17.—F. Quittner: The electrolytic conductivity of glass at high voltages.—L. Moser and M. Niessner: The determination and separation of rare metals: (ix) Beryllium from aluminium. Aluminium can be precipitated along with ferric hydrate, which acts as a flocculating agent. Replacing iron by tannin, the tannin can be used to bring down the aluminium, whilst ammonium acetate retains the beryllium in solution as a complex salt.—H. Neudorfer: The analysis of the principal tangent curves on algebraic net-surfaces.—A. Smekal: Further investigations on deformed crystals of rock-salt.

Official Publications Received.

BRITISH.

Memoirs of the Geological Survey of India. Palæontologia Indica. New Series, Vol. 10, Memoir No. 1: Palæozoic and Mesozoic Fossils from Yun-nan. By Dr. F. R. Cowper Reed. Pp. iv+331+vi+20 plates. (Calcutta: Government of India Central Publication Branch.) 20.9 rupees; 32*s*.

Report of the Kodaikanal Observatory for the Year 1926. Pp. 4. (Calcutta: Government of India Central Publication Branch.) 6 annas.

University of Glasgow. Reports on the Hunterian Collections for the Year 1925–26. Pp. 7. (Glasgow.)

The Half-Yearly Journal of the Mysore University. Vol. 1, No. 1, January. Pp. 92. (Bangalore.) 2 rupees.

Memoirs of the Department of Agriculture in India. Botanical Series, Vol. 14, No. 3: Sugarcane Breeding—Indications of Inheritance. By Rao Saheb T. S. Venkatraman. Pp. 113-129+6 plates. (Calcutta: Government of India Central Publication Branch.) 8 annas; 10*s*.

Rhodesian Museum, Bulawayo. Twenty-fifth Annual Report, 1926. Pp. 15. (Bulawayo.)

The Snake Park, Port Elizabeth. By F. W. FitzSimons. Pp. 32. (Port Elizabeth: Port Elizabeth Museum.)

Institution of Chemical Engineers. Some Industrial Developments and the Chemical Engineer. Presidential Address by Sir Frederic L. Nathan delivered at the Fifth Annual Corporate Meeting of the Institution of Chemical Engineers, held at the Hotel Victoria, London, W.C.2, 11th March 1927. Pp. 7. (London.)

The Scientific Proceedings of the Royal Dublin Society. Vol. 18 (N.S.), No. 33: The Maintenance Requirements of Cattle on Different Rations and at Different Rates of Production; with a Note on 'Dynamic Action.' By James Wilson. Pp. 399-406. (Dublin: Hodges, Figgis and Co.; London: Williams and Norgate, Ltd.) 6*d*.

Annual Report of the Auckland Institute and Museum for 1926–27, adopted at the Annual General Meeting held on 7th March 1927. Pp. 29. (Auckland, N.Z.)

Transactions and Proceedings of the New Zealand Institute. Vol. 57. Pp. x+1123+80 plates. (Wellington, N.Z.)

New Zealand: Dominion Museum. Bulletin No. 8: Games and Pastimes of the Maori; an Account of various Exercises, Games and Pastimes of the Natives of New Zealand, as practised in former Times; including some Information concerning their Vocal and Instrumental Music. By Elsdon Best. Pp. viii+191+67 plates. (Wellington, N.Z.)

The Scottish Forestry Journal: being the Transactions of the Royal Scottish Arboricultural Society. Vol. 41, Part 1, March. Pp. x+104+39. (Edinburgh: Douglas and Foulis.) 3*s*.

FOREIGN.

Statens Meteorologisk-Hydrografiska Anstalt. Årsbok, 6, 1924. 3: Vattenståndеn vid Rikets kuster. Pp. ii+21. (Stockholm.) 2 kr.

Meddelanden från Statens Meteorologisk-Hydrografiska Anstalt. Band 3, No. 10: Sur la structure thermique de l'atmosphère au-dessus de la Suède méridionale; sondages faits par avion en 1924 et 1925. Par F. Lindholm. Pp. 42. 2.50 kr. Band 3, No. 11: De svenska vattendragens arealförhållenden. 4: Piteälv m.fl. Av Gustaf Wersén. Pp. 15. 1.50 kr. Band 3, No. 12: Recording Nocturnal Radiation. By Anders Ångström. Pp. 12. 1 kr. (Stockholm.)

U.S. Department of Agriculture: Weather Bureau. *Monthly Weather Review*, Supplement No. 28: Climatological Data for the Tropical Islands of the Pacific Ocean (Oceania). By W. W. Reed. Pp. iii+22. (Washington, D.C.: Government Printing Office.) 10 cents.

General Guide to the Exhibition Halls of the Peabody Museum of Natural History, Yale University. Prepared by the Curators, edited by Clara M. LeVene. Pp. 54. (New Haven, Conn.) 25 cents.

Astronomical Papers prepared for the Use of the American Ephemeris and Nautical Almanac. Published by the Nautical Almanac Office, U.S. Naval Observatory, by direction of the Secretary of the Navy and under the Authority of Congress. Vol. 9, Part 3: The Orbit of Neptune's Satellite and the Pole of Neptune's Equator. Pp. ii+275-337. (Washington, D.C.: Government Printing Office.)

University of California Publications in American Archaeology and Ethnology. Vol. 22, No. 3: Washo Texts. By Grace Dangberg. Pp. 391-443. (Berkeley, Calif.: University of California Press; London: Cambridge University Press.) 65 cents.

Bulletin of the National Research Council. Vol. 11, Part 3, No. 57: Molecular Spectra in Gases. Report of the Committee on Radiation in Gases. Pp. 358. (Washington, D.C.: National Academy of Sciences.) 4 dollars.

Department of the Interior: Bureau of Education. Education in the United States of America. Prepared under the Direction of Jno. J. Tigert for the Pan Pacific Conference on Education, Rehabilitation, Reclamation and Recreation, Honolulu, T.H., April 11 to 16, 1927. Pp. v+75. (Washington, D.C.: Government Printing Office.) 20 cents.

International Hydrographic Bureau. List of Lifesaving Stations of the World, with their Equipment and Geographical Positions: Liste des Stations de sauvetage du monde entier, avec leur équipement et leurs positions géographiques. By Rear Admiral A. P. Niblack. (Special Publication No. 18.) Pp. 82. (Monaco.) 30 cents.

Conseil Permanent International pour l'Exploration de la Mer. Bulletin statistique des pêches maritimes des pays du nord et de l'ouest de l'Europe. Vol. 14, pour l'année 1924. Pp. 51. Rapports et procès-verbaux des réunions. Vol. 41: Procès-verbaux (Septembre 1926). Pp. 209. (Copenhague: Andr. Fred. Høst et fils.)

CATALOGUE.

Classified List of Second-hand Scientific Instruments. (No. 90.) Pp. vi+58. (London: C. Baker.)

Diary of Societies.

SATURDAY, MAY 7.

ROYAL SOCIETY OF MEDICINE (Otology Section) (at 1 Wimpole Street, W.), at 9.15 A.M.—Annual General Meeting.

BIOCHEMICAL SOCIETY (in Physiology Department, Manchester University), at 3.—Kathleen Culhane and Dr. G. W. F. Underhill: Variations in the Serum Calcium of Rabbits.—F. C. Happold: The Attempted Isolation of a Type Precipitinogen from *B. aertrycke*, Mutton.—P. W. Clutterbuck: Experiments on the Origin of Succinic Acid in Muscle and Liver.—C. E. M. Pugh and Prof. H. S. Raper: The Action of Tyrosinase on Phenols.—E. Boyland and A. D. Ritchie: Chemical Changes in Muscle.—J. Pryde and J. M. Peterson: The Carbohydrate-phosphate Component of Animal Nucleic Acid.—J. Pryde and E. T. Waters: Some Observations on Methylated Glycerophosphates.—T. K. Walker and P. D. Coppock: Fermentation of Propionic Acid by *Aspergillus niger*.—Ellen Stedman and E. Stedman: Hæmocyanin. Part IV. The Dependence of the Shape of the Oxygen Dissociation Curve on the State of Ionisation of the Protein.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS (South-Eastern District) (at Grand Hotel, Dover), at 4.—J. A. Jarvis: Notes of the Earlier Housing Schemes of the Corporation.—W. Bryan: Notes on Housing in the Tower Hamlets District of the Borough of Dover.—F. V. How: The Pier District Improvement Scheme, Dover.—W. B. Smith: Dover—Notes on Recent Municipal Activities.

INSTITUTE OF BRITISH FOUNDRYMEN (Lancashire Branch) (at College of Technology, Manchester), at 4.—E. Longden: Some Aspects of Foundry Work.

MONDAY, MAY 9.

ROYAL IRISH ACADEMY, at 4.15.

ROYAL SOCIETY OF EDINBURGH, at 4.30.—Prof. D. Noël Paton: Submergence and Postural Apnœa (Cessation of Breathing) in the Swan.—Prof. H. G. Cannon: On the Feeding Mechanism of *Nebalia Bipes*.—A. H. R. Goldie: The Structure and Movement of the Atmosphere as affected by Diurnal Variations.—*To be read by title*:—Dr. A. W. Greenwood and Dr. F. A. E. Crew: On the Quantitative Relation of Comb Size and Gonadic Activity in the Fowl.

ROYAL INSTITUTION OF GREAT BRITAIN, at 5.—General Meeting.

ARISTOTELIAN SOCIETY (at University of London Club), at 8.—Miss Hilda D. Oakeley: The World as Memory and as History.

ROYAL SOCIETY OF ARTS, at 8.—J. W. T. Walsh: The Measurement of Light (Cantor Lectures) (3).

BRITISH PSYCHOLOGICAL SOCIETY (Education Section) (at London Day Training College), at 8.—Mrs. Susan Isaacs: The Function of the School for the Young Child.

SURVEYORS' INSTITUTION, at 8.—A. M. Trustram Eve and others: General Discussion on The Practical Application of the Rating and Valuation Act, 1925.

INSTITUTION OF ELECTRICAL ENGINEERS (Western Centre) (at Plymouth).

TUESDAY, MAY 10.

ROYAL SOCIETY OF MEDICINE (Therapeutics and Pharmacology Section) at 5.—Annual General Meeting.

INSTITUTION OF PETROLEUM TECHNOLOGISTS (at Royal Society of Arts), at 5.30.

ZOOLOGICAL SOCIETY OF LONDON, at 5.30.—Dr. R. Broom: On Sphenosuchus, and the Origin of the Crocodiles.—Dr. H. H. Scott: (*a*) Neoplasm in an Indian Rhinoceros; (*b*) Two Cases of Peritoneal Neoplasm (Endothelioma).—C. A. Hoare: Schewiakoff's Keys for the Determination of the Holotrichous Ciliates.—Dr. F. P. Stowell: The Resistance of certain Metals and Metallic Alloys to Corrosion and Solution by Sea-water.

INSTITUTION OF CIVIL ENGINEERS, at 6.—Annual General Meeting.

INSTITUTE OF MARINE ENGINEERS, at 6.30.—H. J. Young: Some Metals and Methods of Use in Marine Engineering.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN (Kinematograph Group), at 7.—A. S. Newman: Inertia Momentum.—A. J. Griffin: The Care of Kiné Negative during Development.

QUEKETT MICROSCOPICAL CLUB, at 7.30.—Dr. D. Ward Cutler: The Effect of External Conditions on Soil Micro-organisms.

WEDNESDAY, MAY 11.

ELECTRICAL ASSOCIATION FOR WOMEN (Annual Meeting) (at Hotel Cecil), at 11.30.—At 3.30 (at Magnet House, Kingsway).—Lecture on Refrigeration and the Pure Food Act.

ROYAL SOCIETY OF MEDICINE (Surgery: Sub-Section of Proctology) (Annual General Meeting), at 5.—W. E. Miles, W. B. Gabriel, and others: Discussion on Colostomy.

GEOLOGICAL SOCIETY OF LONDON, at 5.30.—Prof. P. G. H. Boswell: The Salopian Rocks and Tectonics of the District South-West of Ruthin (Denbighshire).—R. C. Blackie: The Geology of the Country between Llanelidan and Bryneglwys.

ROYAL SOCIETY OF ARTS, at 8.—Prof. W. E. Dalby: English Railways (Dr. Mann Lectures) (2).

INSTITUTE OF METALS (at Institution of Mechanical Engineers), at 8.—Sir Henry A. Miers: The Growth of Crystals in Supersaturated Liquids (Annual May Lecture).

EUGENICS SOCIETY (at Royal Society), at 8.30.—Miss Evelyn Lawrence: Intelligence of Institution Children.

THURSDAY, MAY 12.

ROYAL SOCIETY, at 4.—Election of Fellows.—At 4.30.—Discussion on The Function and Distribution in Living Organisms of Hæmoglobin and Related Substances. Speakers: Prof. J. Barcroft, Dr. H. Hartridge, Sir Frederick Hopkins, Dr. D. Keilin, F. J. W. Roughton, R. Hill, Prof. H. M. Fox, Dr. J. B. S. Haldane.

LONDON MATHEMATICAL SOCIETY (at Royal Astronomical Society), at 5.—Prof. H. F. Baker: Geometry and Differential Geometry (Lecture).

BRITISH SCIENCE GUILD (Annual Dinner) (at Criterion Restaurant), at 7.30.—Speakers: Sir Alfred Mond, Bart., Sir Herbert Samuel, Gen. Sir George F. Milne, Hon. W. Ormsby-Gore, Sir William Pope, Sir Frederick Keeble, Rev. Prebendary Gough.

OPTICAL SOCIETY (at Imperial College of Science and Technology), at 7.30.—Prof. M. von Rohr: Note on the History of English Opticians in the First Half of the Nineteenth Century (with special reference to Spectacle History).

INSTITUTION OF STRUCTURAL ENGINEERS (at 10 Upper Belgrave Street, S.W.), at 8.—A. G. Pugsley: Some Problems in the Design of Steel Roof Truss Members.

OIL AND COLOUR CHEMISTS' ASSOCIATION (Annual General Meeting) (at 8 St. Martin's Place, W.C.), at 8.—A. de Waele: Some Physical Factors influencing Properties of Paint Pigments.

FRIDAY, MAY 13.

ASSOCIATION OF ECONOMIC BIOLOGISTS (at Imperial College of Science and Technology), at 2.30.—Plant Alkaloids:—Lieut.-Col. A. T. Gage: The Principal Plants yielding Alkaloids.—Dr. T. A. Henry: The Biochemistry of the Alkaloids.—Dr. J. Trevan: The Medical Aspects of the Alkaloids.

ROYAL ASTRONOMICAL SOCIETY, at 5.

MALACOLOGICAL SOCIETY OF LONDON (at Linnean Society), at 6.

JUNIOR INSTITUTION OF ENGINEERS, at 7.30.—Dr. H. Chatley: The Stability of Dredged Cuts in Alluvium.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Sir Humphry Rolleston, Bart.: Concerning Old Age.

SATURDAY, MAY 14.

ROYAL SOCIETY OF MEDICINE (Balneology and Climatology Section) (Annual Provincial Meeting) (at Llandrindod Wells).

SUNDAY, MAY 15.

ROYAL SOCIETY OF MEDICINE (Balneology and Climatology Section (Annual Provincial Meeting) (at Llandrindod Wells).

PUBLIC LECTURES.

SATURDAY, MAY 7.

OXFORD UNIVERSITY, at 12.—Sir John Simon: The Labrador Boundary.

SUNDAY, MAY 8.

GUILDHOUSE (Eccleston Square, S.W.), at 3.30.—Ancient Civilisations.

TUESDAY, MAY 10.

KING'S COLLEGE, at 5.30.—Prof. A. Michotte: Problems of Mental Work. (Succeeding Lectures on May 12 and 13.)

ROYAL SCHOOL OF MINES, at 5.30.—Dr. F. F. Blackman: Problems of the Respiration of Plants. (Succeeding Lectures on May 17 and 24.)

UNIVERSITY COLLEGE, at 5.30.—W. H. McLean: National, Regional and Town Development Planning. (Succeeding Lectures on May 17, 24, and 31.)

GRESHAM COLLEGE (Basinghall Street, E.C.), at 6.—A. R. Hinks: Astronomy. (Succeeding Lectures on May 11, 12, and 13.)

THURSDAY, MAY 12.

UNIVERSITY OF BIRMINGHAM (Faculty of Medicine), at 4.—Dr. F. A. E. Crew: Organic Inheritance in Man (William Withering Memorial Lectures). (Succeeding Lectures on May 19, 25, 26, June 1 and 2.)

INSTITUTE OF PATHOLOGY AND RESEARCH, ST. MARY'S HOSPITAL, at 5.—Dr. R. A. O'Brien: Streptococci—their Toxins and Antitoxins.

FRIDAY, MAY 13.

UNIVERSITY COLLEGE, at 5.30.—Prof. J. Burnet: Platononic Problems. (Succeeding Lectures on May 20 and 27.)—At 8.30.—Sir John Rose Bradford: University College, London, and Medical Education (Centenary Celebrations Address).

SUNDAY, MAY 15.

GUILDHOUSE (Eccleston Square, S.W.), at 3.30.—Dr. D. G. Hogarth: The Hittite People and their Civilisation.

CONVENTION.

JUNE 6 TO 9.

CONVENTION OF CANADIAN CHEMISTS (at Quebec).

Supplement to NATURE

No. 3001 MAY 7, 1927

Tyndall's Experiments on Magne-crystallic Action.[1]

By Sir WILLIAM BRAGG, K.B.E., F.R.S.

IN 1845, Faraday made the surprising discovery that the vast majority of substances, not merely iron, nickel, and cobalt, are affected by a magnet: and showed also that the action is repulsive quite as often as attractive. Faraday's results excited the greatest interest and were the starting-point for many other researches. In fact, they paved the way for the work of Thomson and Maxwell, who came thereby to the establishment of the laws of electromagnetism. Among the many workers who followed Faraday was Tyndall, who made certain interesting discoveries relating to the behaviour of crystals in the magnetic field.

A very lively discussion sprang up as to the mode of interpretation of the new discoveries, particularly that of the so-called diamagnetism. On one hand, Faraday was satisfied that he could describe them in terms of his 'lines of force': the majority, including Tyndall, referred everything to the existence of poles, magnetic and diamagnetic. Tyndall's experimental work, and the consequences which he drew from it, were devoted to the support of these views. When Faraday's conceptions prevailed it became clear that Tyndall's interpretation of his own experiments must have been incorrect. His collected account of his researches, published in the well-known "Diamagnetism and Magne-crystallic Action," never became a link in the chain of argument.

The recent analysis of crystal structure by means of X-rays throws some new light on those experiments of seventy years ago. We can see more clearly where Tyndall's conclusions were in error. But at the same time the experiments of Tyndall are seen to be closely related to a modern research of immense importance, that of the effect of stress on the constitution and physical properties of materials.

[1] Discourse delivered at the Royal Institution on Friday, Jan. 21.

FARADAY'S FIRST OBSERVATION OF DIAMAGNETISM.

On Sept. 13, 1845, Faraday made one of his most important discoveries, that of a relation between magnetism and light. He found that when plane polarised light was made to traverse a piece of his 'heavy glass,' a borosilicate of lead, in a direction coinciding with that of lines of magnetic force, the plane of polarisation was rotated. He had thus been successful in showing that the action of a magnet did not require the co-operation of a magnetic substance such as iron for its manifestation, but might be directly connected with a substance of a different kind, namely, glass, and a different activity, namely, light. In the following months he tried to find some other connexion between magnetism and this glass. He floated his glass on a liquid and tried whether he could move it by a magnet, without result. But on Nov. 4 he succeeded in his search.

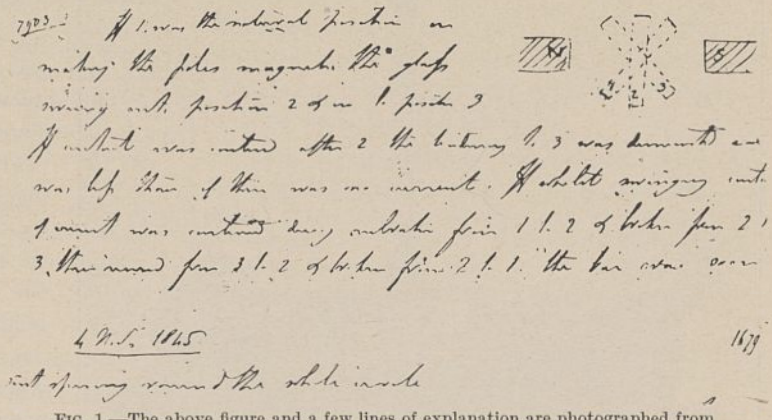

FIG. 1.—The above figure and a few lines of explanation are photographed from Faraday's original notes.

"The bar of heavy glass, $1\frac{6}{8}$ of an inch long and . . .[2] of an inch square, was suspended by cocoon silk in a glass jar in principle as before and placed between the poles of the last magnet. When it was arranged and had come to rest I found I *could* affect it by the magnetic forces and give it position. Thus touching diamagnetics by magnetic curves

[2] Not filled in, but from other notes we know it was half an inch square.

and observing a property quite independent of light by which we may probably trace these forces into opaque and other bodies as the metals, etc."

"If 1 was the natural position on making the poles magnetic the glass swung into position 2 and on to position 3. If contact was united after 2 the tendency to 3 was diminished, *i.e.* was less than if there was no current. If whilst swinging contact of current was continued during vibration from 1 to 2 and broken from 2 to 3, then united from 3 to 2 and broken from 2 to 1 the bar was soon sent spinning round the whole circuit" (see Fig. 1).

The word 'diamagnetic' is here used to denote substances through which, on his views, magnetic lines were passing. It is not yet used as an anti-

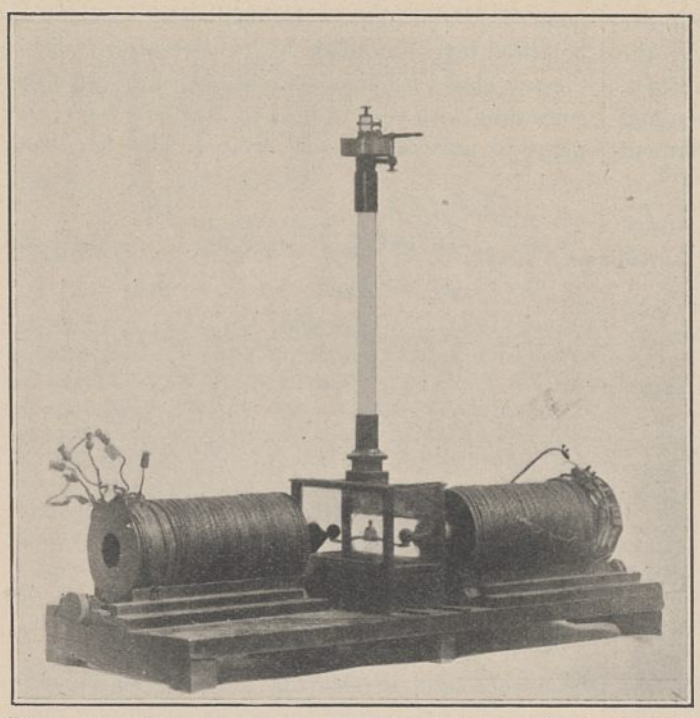

FIG. 2.—Apparatus used by Tyndall. Two balls of bismuth are placed at opposite ends of an arm swinging at the end of a suspension thread. The electromagnets are staggered so as to combine their actions in turning the arms by means of the repulsive forces exerted on the balls. ("Diamagnetism and Magne-crystallic Action," p. 53.)

thesis to 'paramagnetic.' His new result obviously gave him intense pleasure, and in following it up he was so preoccupied that he did not even go to the meeting of the Royal Society on Nov. 20 when his paper on the "Action of Magnets on Light" was read.

We can easily repeat the experiment, using a piece of the same glass taken from the store left by Faraday. It is not the actual piece, Number 174, as he tells us in his notes, for this cannot be found. The glass turns slowly in the magnetic field, and its motions are obviously controlled by switching the current off and on. The glass tends to set itself *across* the lines of force running from pole to pole, not *along* the lines as a piece of iron would do; and obviously the effect is very small as compared with the violent movements of iron in the same circumstances.

The action may be described as a repulsion of the glass by the magnet: and sometimes the early workers on the subject constructed apparatus specially designed to show the repulsive effect more obviously, and to distinguish it from a mere turning action in a magnetic field, if indeed this could be done. We can illustrate this point, and at the same time the diamagnetism of bismuth, by using a piece of apparatus constructed for Tyndall (Fig. 2).

FARADAY'S FIRST EXPLANATION OF DIAMAGNETISM.

Faraday at first suggested that the diamagnetic effect was the antithesis of the ordinary magnetic effect. A piece of iron when placed between two poles became so magnetised that a south pole was developed upon it in that part which was nearest to the north pole of the inducing magnet and vice versa. Faraday's suggestion that the diamagnetic substance developed north and south poles where a magnetic substance would have developed south and north respectively was taken to be a satisfactory explanation. It was the constant endeavour of later experimenters to express their results in accordance with Faraday's hypothesis: even when development had reached a stage some distance ahead of that described in the original paper (*Phil. Trans.*, 1846, p. 21).

Faraday was himself the first to feel doubts as to the satisfactory nature of his explanation. His early results could conveniently be described as showing an exact antithesis between two classes; where one was attracted by a magnet, the other was repelled: where one set itself in a certain direction in the magnetic field, the other avoided that direction as much as possible. It seemed proper to describe them as being in exact antithesis to each other, and the word diamagnetism was adopted as a means of expressing the experimental result.

He prepared a list of substances which showed varying degrees of response to the action of the magnetic field, and the plan of the statement illustrates his first views ("Experimental Researches," Series xxi. No. 2424):—

"Iron	Alcohol
Nickel	Gold
Cobalt	Water
Manganese	Mercury
Palladium	Flint glass
Crown-glass	Tin
Platinum	Heavy glass
Osmium	Antimony
0° Air and vacuun	Phosphorus
Arsenic	Bismuth"
Æther	

It is to be observed that those preceding air and vacuum are to be considered above zero or magnetic, those succeeding, below zero or diamagnetic, which is meant to imply a true antithesis.

In Dec. 1845 ("Experimental Researches," Series xxi. No. 2429), Faraday writes :

"Theoretically, an explanation of the movements of the diamagnetic bodies, and all the dynamic phænomena consequent upon the actions of magnets on them, might be offered in the supposition that magnetic induction caused in them a contrary state to that which it produced in magnetic matter ; *i.e.* that if a particle of each kind of matter were placed in the magnetic field both would become magnetic, and each would have its axis parallel to the resultant of magnetic force passing through it ; but the particle of magnetic matter would have its north and south poles opposite, or facing towards the contrary poles of the inducing magnet, whereas with the diamagnetic particles the reverse would be the case ; and hence would result approximation in the one substance, recession in the other."

Even at that time, however, Faraday's views were not firmly established : and we may repeat an experiment of his which shows the nature of the contrary influences that were impressing him. A small glass tube filled with a weak solution of the magnetic substance iron sulphate sets itself axially between the magnetic poles ; but if it is surrounded as it swings by a strong solution of the same substance, it sets equatorially. The tube appears to be magnetic as compared to air, but diamagnetic as compared to the strong solution.

Might not, on this analogy, all substances, and also air and vacuum, be magnetic, reacting to the magnet in the same way but to different degrees ? And might not bismuth exhibit its peculiarities, not because it is in antithesis to iron, but merely because it is less magnetic than the air ? Yet he writes as follows :

"Such a view also would make mere space magnetic, and precisely to the same degree as air and gases. Now though it may very well be, that space, air and gases, have the same general relation to magnetic force, it seems to me a great additional assumption to suppose that they are all absolutely magnetic, and in the midst of a series of bodies, rather than to suppose that they are in a normal or zero state. For the present, therefore, I incline to the former view, and consequently to the opinion that diamagnetics have a specific action antithetically distinct from ordinary magnetic action, and have thus presented us with a magnetic property new to our knowledge" ("Experimental Researches," Series xxi. No. 2440, Dec. 1845).

The extract describes his first-formed opinion.

Plücker's Discovery of Magne-crystallic Action.

The next important step is due to Plücker :

"In 1847, Plücker had a magnet constructed of the same size and power as that described by Faraday, his object being to investigate the influence of the fibrous constitution of plants upon their magnetic deportment ; while conducting these experiments he was induced to try whether crystalline structure exercised an influence" (Tyndall, "Diamagnetism and Magne-crystallic Action," p. 2).

The first experiment made by Plücker gave an immediate and decided reply. The investigation of the behaviour of several crystals led him to announce the following laws :

"When any crystal whatever with an optic axis is brought between the poles of a magnet, the axis is repelled by each of the poles ; and if the crystal possesses two axes, each of these is repelled with the same force by the two poles.

"The force which causes this repulsion is independent of the magnetism or diamagnetism of the mass of the crystal ; it decreases with the distance more slowly than the magnetic influence exerted by the poles."

There is some truth in Plücker's conclusions, but much correction is necessary. Tyndall pointed out in 1850 that they broke down completely when applied to calcium and iron carbonate. These two crystals are isomorphous ; the former, Iceland spar, obeys Plücker's laws in that it sets its axis equatorially in the magnetic field, but iron carbonate sets its axis from pole to pole. Plücker had, however, done great service in directing attention to the peculiar behaviour of crystals in the magnetic field.

In the autum of 1848 Plücker was in London. Faraday writes in his laboratory notes :

"16 Aug. 1848. Plücker has described to me certain of his results as to the crystalline diamagnetic relation and, as I understand it, the optic axis of a crystal having *one* optic axis tends to pass into the equatorial direction, or if a crystal have two optic axes then the line between them tends to pass into the equatorial direction."

"25 Aug. 1848. To-day Plücker showed me for the first time some of his experiments.

"First Optical Results.

"A small rhomboid of Cal^{e} Spar was suspended by a single cocoon thread between my Elect. Magnet poles with the optic axis in a horizontal position. When the poles were very close as in the figure the diamagnetic force of the substance made it take the position shown in which the optic axis is axial to the magnet. But when the poles were opened out to distance of half or threequarters of an inch, then the mass pointed axially and the optic axis therefore equatorially [see Fig. 3]. . . . There is a given distance between the Mag poles (pretty close) when a certain or piece rhomboid ∧ of Cal^{e} spar between them is so affected that the diamagnetic and the magneto-optic force is balanced, at smaller distances the piece points diamagnetic and at larger distances Magneto optic. So that on increasing the distance the magneto-optic force diminishes *less rapidly* than the magnetic force, and on diminishing the distance it increases less rapidly than the magnetic force. *But increasing or diminishing the strength of the magnet produces no alteration of this place of neutral action, it only increases or diminishes the strength of the action on each side of it: or rather the resultant of the two actions on each side of that neutral position.* So Plücker at least tells me, for I did not see that proved."

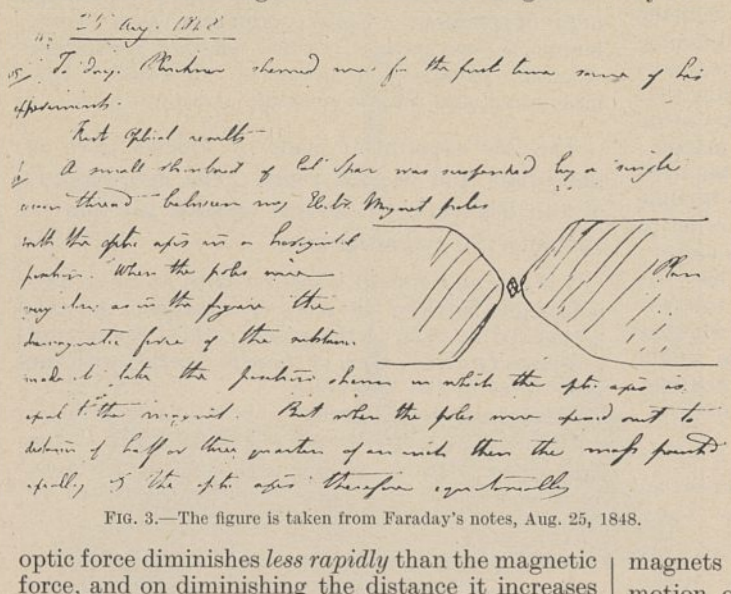

Fig. 3.—The figure is taken from Faraday's notes, Aug. 25, 1848.

Plücker's experiment is readily shown; but a little care in adjustment is required. The dimensions of an equal-sided rhomb are rather too much the same in all directions: a somewhat more irregular piece is, I find, easier to work with. The effect is much more clearly seen with a good bismuth crystal, which was obtained in the following way. A little bismuth was melted in a glass tube which had been drawn to a point. The tube was placed in an electric furnace, from which it was made by clockwork to emerge very slowly. The fine end of the tube came out first, and the bismuth at the point was the first to solidify into crystalline form. The rest of the metal crystallised slowly as the emergence proceeded, and, in the circumstances, continued the structure and orientation of the first fragment. In this way, due to Bridgeman, the mass contained large single crystals, not a mass of fine crystals as is usual when the solidification takes place rapidly.

When the crystal, which is ten times as long as it is broad, is placed in the magnetic field due to pointed poles, it sets strongly equatorially in accordance with the usual behaviour of a diamagnetic body: but when the poles are withdrawn somewhat, it sets axially with equal strength.

The experiments of Plücker introduced a new effect which Faraday afterwards called "magne-crystallic action." It clearly deserved a name, since its manifestations added a complication to the diamagnetism which had already been observed.

The new discoveries presented so many forms when repeated with different crystals suspended in different ways and with different forms of magnetic field that the complications were not unravelled for some years. Some of the difficulties were due to the circumstances of the experiments and had no relation to the real question. One of these incidental effects was that of attractions and repulsions due to transient currents induced in bodies already suspended for observation between the magnetic poles when the magnets were excited. As is well known, the motion of a spinning block of copper is at once arrested by the action of such currents; on the other hand, a sheet of copper held near a pole is sharply repelled when the current is turned off, and if properly suspended can be set into a rapid spinning. These effects had nothing to do with diamagnetism, but they were apparently the cause of confusion on some occasions.

Another great source of difficulty was the overpowering effect of iron impurities; the diamagnetic effects are so feeble in all cases that a mere trace of iron, nickel, or cobalt is sufficient to mask them. So, for example, Plücker's experiments with antimony seem on this account to have been at variance with the true facts as proved by Faraday (Tyndall, p. 16).

Faraday's Researches on Magne-crystallic Action.

In 1848, Faraday published a series of researches on the magne-crystallic phenomena, which cleared

up some of the difficulties. But in 1850 he could still write as follows :

"Four years ago I suggested that all the phenomena presented by diamagnetic bodies, when subjected to the forces in the magnetic field, might be accounted for by assuming that they then possessed a polarity, the same in kind as, but the reverse in direction of, that acquired by iron, nickel, and ordinary magnetic bodies under the same circumstances. This view was received so favourably by Plücker, Reich, and others, and above all by W. Weber, that I had great hopes it would be confirmed ; and though certain experiments of my own did not increase that hope, still my desire and expectation were in that direction. (2641) Whether bismuth, copper, phosphorus, etc., when in the magnetic field are polar or not is, however, an exceedingly important question ; and very essential and great differences in the mode of action of these bodies under the one view or the other, must be conceived to exist. I found that in every endeavour to proceed by induction of experiment from that which is known in this department of science to the unknown, so much uncertainty, hesitation, and discomfort arose from the unsettled state of my mind on this point that I determined if possible to arrive at some experimental proof either one way or the other. This was the more important because of the conclusion in the affirmative which Weber had come to in his very philosophical paper. . . . (2642) It appeared to me that many of the results which had been supposed to indicate a polar condition were only consequences of the law that diamagnetic bodies tend to go from stronger to weaker places of action ; others, again, appeared to have their origin in induced currents. . . ."

Accordingly, he undertook a further series of researches which in the end brought him to regard all his effects as expressible in the simple form with which we are familiar. In his "Experimental Researches" he writes (Ser. xxvi., Oct. 1850, No. 2807) :

"When a paramagnetic conductor, as for instance a sphere of oxygen, is introduced into such a magnetic field considered previously as free from matter, it will cause a concentration of the lines of force on and through it so that the space occupied by it transmits more magnetic power than before. If, on the other hand, a sphere of diamagnetic matter be placed in a similar field it will cause a divergence or opening out of the lines in the equatorial direction, and less magnetic power will be transmitted through the space it occupies than if it were away" (see Fig. 4).

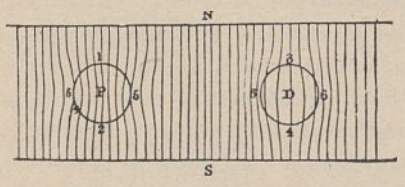

FIG. 4.—The figure is taken from Faraday's "Experimental Researches," and was drawn to show his conception of the passage of lines of magnetic force through paramagnetic and diamagnetic bodies respectively.

This describes diamagnetism generally : the complication of magne-crystallic action is described with equal simplicity :

"(2837) If the idea of conduction be applied to these magne-crystallic bodies it would seem to satisfy all that requires explanation in their special results. A magne-crystallic substance would then be one which in the crystallised state could conduct onwards, or permit the exertion of the magnetic force with more facility in one direction than another : and that direction would be the magne-crystallic axis. Hence, when in the magnetic field, the magne-crystallic axis would be urged into a position coincident with the magnetic axis by a force correspondent to that difference, just as if two bodies were taken, when the one with the greater conducting power displaces that which is weaker."

It is only a uniaxial crystal, of course, which possesses a single magne-crystallic axis ; it is the axis of a certain spheroid. The facility of conduction in different directions in a biaxial crystal requires an ellipsoid for its representation.

This way of stating the rules allows us to see at once the principle of the experiments shown by Plücker to Faraday, which the latter so greatly extended. When the magnet poles were close, the crystal occupied a part of the field where the lines of force were very divergent. In such circumstances the orientation of the crystal would be determined by the general tendency for diamagnetic bodies to move from the stronger to the weaker parts of the field, and the crystal set its longer dimension perpendicular to the field ; the optic axis was then parallel to the lines of force. But when the magnetic poles were separated the crystal covered a part of the field in which there was little divergence : the magne-crystallic action then took charge, and the crystal set itself so that the direction of worst conduction of the lines, *i.e.* the optic axis, was at right angles to the lines.

Experimental Illustration of Magne-crystallic Action.

A few simple experiments will serve as further illustration of these rules. We take a crystal of sulphate of iron which has the form of a thin plate : the flat sides are cleavage planes and the 'conducting power' for Faraday's lines is far greater across the plate than along the large faces. In a uniform field the crystal plate sets equatorially therefore, and even when allowed to move up to one of the poles keeps its face normal to the lines. A thin plate of iron would stand on edge on the pole : but the magne-crystallic action of this paramagnetic crystal is exceedingly strong.

A bismuth crystal so suspended that its axis (it is a uniaxial crystal) is vertical has no magne-crystallic action. Its motions are governed by the general tendency of its mass to move from the stronger to the weaker parts of the field: in a uniform field it has no appreciable tendency to set itself in any particular direction. But when the crystal is hung so that the axis is horizontal, that axis tends strongly to set itself along the lines of force, as we saw before.

Naphthalene is a monoclinic crystal. Its magne-crystallic properties are represented by an ellipsoid, one axis of which coincides with the single axis of symmetry. The cleavage is very perfect and the crystals take the form of thin plates parallel to the cleavage planes. The axis is also parallel to the cleavage planes, and if the crystal is suspended so that this axis is horizontal and the cleavage planes vertical, the axis and the planes move into the equatorial position, in this way fulfilling symmetrical considerations. But when the crystal is hung in a uniform field, so that the axis is vertical, the cleavage planes set themselves at a certain angle to the field. One of the axes of the magnetic ellipsoid then lies along the lines, another across them: the third is vertical. There is no obvious relation between the cleavage plane and the first two axes. Finke (*Annalen der Physik*, **31**, 149; 1910) has shown that this may be said of various crystals examined by him. If now the crystal be suspended from the other end of the axis, its cleavage planes will make the same angle with the field but on the opposite side of the medial line (Fig. 5). Faraday describes results of this kind which he obtained with a paramagnetic crystal of sulphate of iron ("Experimental Researches," Series xxi. Nos. 2634-7). Naphthalene is diamagnetic: like many other organic crystals, it shows the magne-crystallic effect very strongly.

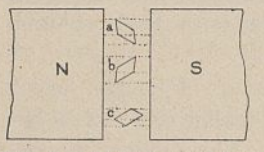

FIG. 5.—In this figure the positions marked *a* and *b* are positions of equilibrium of the naphthalene crystal in the magnetic field. The axis of symmetry is vertical and perpendicular to the plane of the paper. The cleavage plane is also vertical and its intersection with the plane of the paper is the longer side of the rhomboid. The form of the crystal shown in the figure is not a natural form, because the shorter side of the rhomboid is drawn parallel to one face of the cell of the crystal lattice, which face does not usually occur on the crystal. It is so drawn in order to show the relation between magnetic lines and the lattice.

If the crystal is hung from one end of the *b* axis, the position *a* is assumed, and if from the other, the position *b*. The position *c* is impossible.

These experiments will serve to show the great variety of effects that may be observed. All of them are, however, easily correlated by Faraday's conception of lines of force. Let us remember that there are several variables and give due importance to each. The first of these we call diamagnetism, implying that the lines pass through the substance in question less easily than through the air or a vacuum. The second is called magne-crystallic action, in reference to the fact that in a crystal the lines pass more easily in one direction than another. A third variable is the crystal shape, which may also affect the set in the magnetic field when the latter is divergent. A fourth is the amount of divergence of the field which, in a uniform field, falls to zero. After experimental disturbances have been allowed for, all these influences have to be taken into account.

The more divergent the field the more does the simple diamagnetic effect assert itself, and any magne-crystallic action which would tend to make the specimen set a crystal axis or axes at some particular inclination to the direction of the field is overpowered.

The Contrast between Paramagnetism and Diamagnetism.

On the other hand, magne-crystallic action usually takes charge in a truly uniform field. For the sake of brevity and an easier explanation, it may be well to direct attention to a fact which was not fully appreciated by all the first experimenters, but was clearly set out by Sir William Thomson (Lord Kelvin) in 1885. A diamagnetic bar, apart from magne-crystallic action, tends to set itself *along* the lines of force in a *uniform* field, just as a paramagnetic bar. For we may imagine the bar to be made up gradually of a collection of cubes, placed successively one after the other in the magnetic field. The effect of the first cube is, as we should say in the language of Faraday, to spread out the lines of force on their way through the cube, and to crowd them together on either side of it. A second diamagnetic cube will, if free to move, go to that part of the field where the lines are least crowded; it will therefore avoid setting itself beside the first cube and prefer to place itself in front or behind it. A third will continue the same process, and in the end the cubes will form a bar pointing along the lines. In the case of a substance such as iron, there is a double converse.

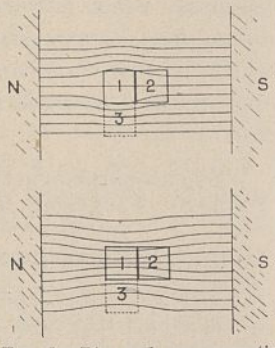

FIG. 6.—Dia- and paramagnetic substances in a magnetic field. In both cases Position 2 is preferred to Position 3.

The lines are most dense just in front and just behind the first cube; and a second cube will place itself in one of those positions because a magnetic substance seeks the strongest part of the field. Again, therefore, the bar grows along the lines, as in this case we know from experience (see Fig. 6).

It is quite certain that no one has ever seen the first of these effects, because it must be so minute and difficult to separate from others. We may safely infer it, as Thomson pointed out, because our theories of the electromagnetic field have been abundantly justified by other means. The susceptibility of bismuth, by far the most diamagnetic substance, is only about 10^{-6}; in other words, the strength of the field on one side of a bismuth cube of 1 cm. side would only be about a thousandth part of 1 per cent. greater than at the front or back of the cube. Near a pointed pole the strength of the field might easily vary by 50 per cent. in a centimetre. It is easy to see how feeble is the force tending to arrange the supposed cubes parallel to the lines of a uniform field as compared with the forces acting on a bar placed near the pole.

The analogous effect in electrostatics can, however, be realised. When two plates are immersed in oil and maintained at a large difference of potential, an elongated rod of glass hung from a fibre sets itself along the lines of force (to make sure that the effect is true the rod must be free from any conductivity due to its own substance or a water film). This corresponds to the setting of a magnetic body in a uniform field. When bubbles of air are allowed to rise through the oil they are [3] drawn out along the lines of force; which effect, since the inductivity of air is less than that of oil, represents the setting of a diamagnetic body along lines of magnetic force.

When a diamagnetic substance sets itself across the lines of a magnetic field, and no magne-crystallic action is at work, it is because the field is not really uniform. It is perhaps a little confusing when it is said, as is sometimes the case, that diamagnetic and paramagnetic substances are the antitheses of one another in that one kind sets itself across the field and the other along it. This is only true of a field which is non-uniform. Indeed, it may be said that the use of the word antithesis is incorrect in any case. There would be a true antithesis if one substance could be defined by its pointing along the lines of force in one direction while another pointed in exactly the opposite direction; there is no true antithesis between pointing along the lines and pointing across them. It seems to me, though I say it with diffidence, that this difficulty was stirring in Faraday's mind and was the true cause of the uneasiness of which he spoke in a quotation given above, and of his aversion to the description of diamagnetism and paramagnetism as being the antitheses of one another.

Faraday, as I have said, when this thorough examination of the facts had led him to frame a hypothesis which would link them together, based his interpretation on the existence of lines of force, and found himself able to place both his own results and those of others in their place within a self-contained system.

Kelvin placed this hypothesis in mathematical form, thus completing the treatment of the subject of magnetism by Poisson; the latter had left out of his consideration the consequence of magnetic susceptibility being different in different directions, not because he overlooked the possibility of such an effect, but because no case of its occurrence was known to him.

The Hypothesis of Polarity.

Faraday's views were not accepted, however, by other experimenters on the same subject, and in particular by Tyndall. The idea of polarity was not to be given up easily, and innumerable experiments were made to show that a 'diamagnet' had poles like a magnet, but in the opposite sense. A bar of bismuth would develop north and south poles when, in similar circumstances, a bar of iron would develop south and north. Of course, when the facts are prepared for mathematical treatment, they can be expressed in this way. It is generally convenient and justifiable to represent a magnet by two poles because the form of the field at any reasonable distance is satisfactorily represented thereby, though in the immediate neighbourhood the lines of a real magnet do not run like those of the theoretical bipole. Within the body of the magnet the lines run from the south pole to the north, continuing and completing their course outside so that every line is a closed circuit; but all lines near a bipole run from the north pole to the south pole. So also in the magnetic shell, which is in the mathematical treatment the exact analogue of the electrical condenser, the bulk of the lines run from one plate to the other across the narrow space between the two plates; comparatively few run from the outside of one plate, through surrounding space, to the back of the other. In the condenser, the internal field is the most important, the external being looked on as a correction. In the magnetic shell the reverse is the case; the outside

[3] My authority is Capt. Dunsheath of the Henley Telegraph Works Co.

field is that which is considered because it represents more and more closely, as the plates are brought closer together, the field due to a current circulating about the contour of the condenser. The theoretical charges on the plates have to be made larger and larger as the plates are brought together, so that the strength of the outside field may remain the same.

Now, if a piece of bismuth is placed along the lines of a magnetic field, the lines avoid the piece to some extent, though, as already explained, the avoidance is extremely small. If we take the bismuth away and replace it by a feeble bipole consisting of south-pole magnetism, of proper amount, where the lines come out of the bismuth, and a corresponding amount of north-pole magnetism where they go in, the whole arrangement being made in a vacuum, or permissibly, in the air, we get (Fig. 7) in this artificial way an external field resembling that which exists when the bismuth is in place. It can be said that polarity is developed in the bismuth in a sense opposite to that which is found in iron in the same circumstances. If the effect is to be represented, for the convenience of treatment, as due to the presence of a bipole, then the sense of the bipole in the case of bismuth is opposite to the sense in the case of iron. The old argument, therefore, was not between two hypotheses but between two languages in terms of which the facts were to be described. Such an antagonism, once believed in and debated, could be and was the cause of an immense variety of experiments devised to justify one side or the other. But Faraday felt that his way of putting the facts was more fruitful in suggestion of further experiments, and more convenient as a foundation for theoretical development. He has been abundantly justified.

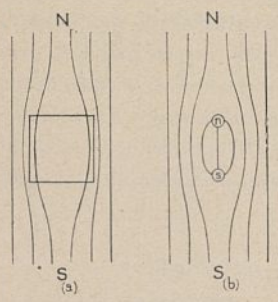

FIG. 7.

THE WORK OF TYNDALL AND KNOBLAUCH.

We now come to the part which Tyndall played in a debate which was conducted on both sides in such an able and, it is pleasant to observe, in such a friendly way. In the first place, Tyndall and Knoblauch published in 1850 an account of experiments which they had made. They showed that Plücker's first views, those which included the repulsion of the optic axis of a uniaxial crystal by the poles of the magnet, were, as already stated, incorrect in many cases, and they substituted an amended set of rules in the following terms :

"If the arrangement of the component molecules of any crystal be such as to present different degrees of proximity in different directions, then the line of closest proximity, other circumstances being equal, will be that chosen by the respective forces for the exhibition of their energy. If the mass be magnetic this line will set axial; if diamagnetic, equatorial."

The key-word is "proximity." This condensed statement of course requires explanation. Tyndall supplies it in full in his book on "Diamagnetism and Magne-crystallic Action." A very brief summary will be sufficient for our present purpose. In the first place, the observations made by him and his partner on the behaviour of crystals in the magnetic field convinced them that the plane of cleavage determined in a number of cases the position which the suspended crystal would take. Magnesium sulphate, zinc sulphate, saltpetre, and topaz were diamagnetic substances, and their cleavage planes, the crystals being so suspended that these planes were vertical, always set themselves equatorially, *i.e.* at right angles to the field. On the other hand, nickel sulphate, scapolite, and beryl, which were magnetic crystals, in the same circumstances set their cleavage planes parallel to the field.

The connexion between these results and the statement quoted above lies in this, that the molecules in a crystal were supposed to be in greater proximity along a cleavage plane than in any other direction. Let us take bismuth as an example; it is diamagnetic and sets its cleavage plane equatorially in accordance with Tyndall's rule. Its structure has now been determined by X-ray analysis, so that we can see what meaning can be attached to the claim for proximity in the plane of cleavage. The bismuth structure can be looked on, approximately, as a slightly distorted cube; one of the cube's diagonals has been a little stretched, while the other three have been left unchanged. The crystal is therefore uniaxial; the axis is the stretched diagonal. The principal cleavage plane is perpendicular to the axis. The spacing of the planes parallel to the cleavage is larger than that of any other set of planes in the crystal, and these consequently contain more molecules to the unit area than any other planes. Tyndall would have said that in those planes there was a maximum proximity between the molecules.

The X-ray analysis of other crystals often shows the cleavage plane to have the largest spacing and

therefore the closest degree of packing. This means that the points of the crystal lattice are closest together in that plane, but it does not mean that the atoms or molecules are nearer together in that plane than in any other. Nothing can be said about that until the actual distribution of the atoms in the unit cell has been determined. It would be much safer to say that the existence of a cleavage plane implies a certain *looseness of packing across* the crystal planes which are parallel to the cleavage. This would imply a greater tightness in other directions, but not necessarily a greater proximity. It is only at first glance that the latter term seems to have a clear meaning. But we must let it stand in order to realise the argument as it presented itself to the authors of the statement quoted.

It happens that in the case of bismuth we do actually find a closer bonding between the atoms in the cleavage plane than in any other; but this is peculiar to the structure of bismuth and has no relation to the supposed close proximity of *molecules* in the cleavage plane.

Now we come to the essential point of the argument. It is supposed that proximity offers magnetism or diamagnetism, whichever it may be, the opportunity to "exhibit its greatest energy." We are to remember that the hypothesis on which we are working expresses itself in terms of poles and that a magnet attracts a piece of iron by inducing poles in it, which poles then react with the poles of the magnet. When a piece of iron is allowed to attach itself to a magnet, the poles induced in it are much stronger than if the magnet and the iron are separated by a little distance. If a second piece of iron is brought near the first, every increase in its proximity increases the strength of the poles which are developed in this piece by the influence both of the original magnet and of the first piece of iron.

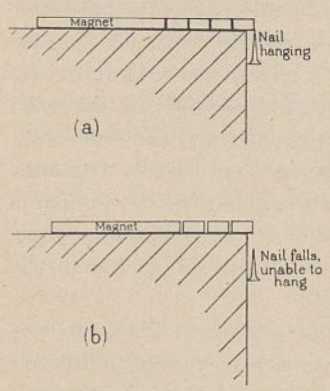

FIG. 8.—When pieces of iron are all in contact with one another and the end one with the magnet, the nail can hang as shown in (*a*). But when, as in (*b*), the iron blocks are somewhat separated from one another and from the magnet, the nail falls.

A simple experiment will serve as an illustration (Fig. 8): The nail hangs in the first case, and not in the second, because the close proximity of the iron blocks increases the strength of the poles in all of them. In the second case, the nail will not hang, although the magnet is actually closer to it. The benefit of mutual 'proximity' of the separate pieces of iron is obvious. An equally simple explanation can be given in terms of lines of force, but we are using the alternative language.

Chains of iron fragments form readily between magnet poles of opposite nature. A rod of iron "transmits the magnetic force," and generally acts more efficiently than a set of iron fragments which are not allowed to get into close proximity with each other. Tyndall sticks short lengths of iron wire through disc-shaped pieces of apple and shows that the disc sets itself at right angles to the field, the bits of wire therefore lying parallel thereto. In each bit are many molecules of iron in close proximity, and the fact is more effective in directing the apple than the existence of a number of bits scattered over the disc without being in 'proximity' to each other.

Diamagnetism and 'Proximity.'

It is now argued by Tyndall that if the magnetic influence of a magnet is extended by means of proximity, the diamagnetic influence must be extended in the same way. If the close proximity of iron fragments will help them to set with greater firmness in the direction joining opposite poles, then the closer proximity of bismuth fragments should cause them to set with greater firmness across them. In this way Tyndall interpreted the rule, which he believed he had established, that the cleavage planes of magnetic crystals tended to set axially, and those of diamagnetic crystals equatorially.

It is interesting to observe that Tyndall was attempting to supply both a rule for the setting of crystals and an explanation of the rule in terms of structure. Faraday stopped short when he had supplied a picture of the distribution of his magnetic lines, or, as we should now say, a map of the distribution of energy in the magnetic field.

As I have already pointed out, there is no clear meaning to the term "greater proximity in the cleavage plane." Moreover, if conclusions were to be drawn from analogy with phenomena on a larger scale, they would run contrary to the intended argument; for, on that scale at least, a line of diamagnetic masses tends to set itself axially, not equatorially. A piece of bismuth makes an extremely minute alteration in the disposition of the lines of force, for which reason it is a very poor detector of the existence of the lines in comparison with iron; and the change, since it is so small, can indeed be detected by a piece of iron in the form of a magnet, but certainly not by

another piece of bismuth, no matter how close they are together.

In the case of a uniaxial crystal, a principal cleavage must from symmetry considerations be related to the axis and, if it is unique, must be perpendicular thereto. When there is more than one cleavage, the cleavage planes must be symmetrically disposed about the axis as in the case of Iceland spar. It is not, therefore, surprising that, in the former case, the cleavage plane should place itself exactly, either equatorially or axially, and that in the latter case a plane perpendicular to the axis might be looked on as a resultant of cleavage planes and therefore set itself equatorially. But it does seem remarkable that, as Tyndall pointed out, the substitution of iron for calcium in Iceland spar, to form the isomorphous iron carbonate, should turn the structure round through 90° in the magnetic field; especially if we assign diamagnetism and paramagnetism to different causes. It may be there are other cases of the same change; and any rule of this kind must clearly be of importance.

The Effects of Pressure on Magnetic Susceptibility.

We now come to another set of experiments, very interesting and important, which were used by Tyndall in the defence of the 'polarity' position. The method of these experiments was suggested by an accident. When working in Berlin with a fine magnet placed at his disposal by Magnus, he was observing the action of the magnet on a bismuth cube which was so shaped that two opposite faces were perpendicular to the optic axis and parallel to cleavage planes. When the current was switched on, the magnet poles rushed together because the separate parts of the magnet had not been properly bolted down. The bismuth cube was crushed to some extent. Working conditions having been restored, it was found that the bismuth set itself at right angles to its former position. The line of pressure, which, of course, had been parallel to the field, was now perpendicular to it. Tyndall now argued that the particles of bismuth had been brought into greater proximity by the pressure and that the setting of this line of great proximity was in accordance with the rule given by himself and Knoblauch. So began an extended series of researches on the effects of pressure which are fully described in his book. As an example let us take the following:

"A quantity of bismuth was ground to dust in an agate mortar, gum-water was added, and the mass was kneaded to a stiff paste. This was placed between two glasses and pressed together; from the mass when dried two cubes were taken, the line of compression being perpendicular to two of the faces of each cube and parallel to the other four. Suspended by a silk fibre in the magnetic field, upon closing the circuit the line of compression turned strongly into the equatorial position. . . ."

When carbonate of iron was used the line of pressure set axially.

Such an experiment is very striking, whatever its explanation may be. Tyndall argued that he had by compression increased the proximity along the line of pressure, but it is difficult to see how this can be. If a number of particles of one kind are distributed with complete irregularity in a paste medium which is then subjected to pressure in one direction, the alteration in form of the paste block will not alter the law of distribution of the particles. In any case, as we have already seen, proximity does not produce any observable effects.

Lord Kelvin's Explanation of Tyndall's Results.

It is surely natural to suggest that the particles acquired some orientation from the pressure, which might well happen if they possessed shapes which were related in some particular way to their structures. Thomson immediately pointed this out to Tyndall, who replied that if that were the case, the bismuth fragments being naturally in the form of flakes parallel to the cleavage plane, the line of pressure ought therefore to set itself axially, whereas it actually set equatorially. This was certainly a good reply. Perhaps the counter argument is that the crystal fragments have not actually been shown to set in this way. Miss Knaggs has made an X-ray measurement of the set of the fragments in one specimen of squeezed dough containing bismuth particles, and has found that the cleavage planes are not closely coplanar with the surface, as they must be if Tyndall's argument is to be good. Though this is a single example, it looks as if a way of escaping the difficulty was to be found.

As I have said, Tyndall's reply to Thomson was good, but, to use his own words, though it formed "a strong presumptive argument it was not yet convincing." He strengthened his case greatly by a further experiment. Comparing the repulsion exerted by a magnet on a natural crystal of bismuth with that exerted on a mass of compressed powder in dough, he found the latter greater than the former. He had cut the crystal into the form of a cube and placed it on one arm of a torsion balance

so that the cleavage plane was perpendicular to the magnetic field, and the repulsive force as great as it could possibly be. The dough had been pressed into a cube of the same size and placed with its line of pressure at right angles to the field. Tyndall argued that there must be a direct effect of pressure, since it had done more than all that the natural phenomena could do.

Now it is clear that if the orientation of a bismuth crystal in a uniform magnetic field, *i.e.* the magne-crystallic action, is due to the arrangement of the atoms and molecules in the crystal structure, the perfect crystal ought to show the effect more perfectly than the fragments distributed through the dough, however perfectly the latter may be arranged. But Miss Knaggs has made an X-ray photograph from the face of a natural 'crystal.' The specimen was chipped out of a mass of crystals left in a crucible, and must have resembled that which Tyndall used. The photograph showed at once that the specimen was a compound of more than one crystal, and that different orientations were present. Cleavage planes, and also others which in a single crystal would make large angles with the cleavage planes, were nearly parallel to the face under test. It is possible, therefore, that there was really more of the effective orientation in the pressed specimen than in the natural piece. A photograph of the single crystal made by Bridgman's method taken in the region of the cleavage plane gave a much cleaner picture.

A piece of bismuth can be looked on as an aggregate of crystals. There may be but one perfect crystal or there may be a number, small or large, of smaller crystals, each perfect. If proximity were increased by pressure, the change in proximity would have to occur in respect to the mutual distances in either of the separate crystals, or of the atoms and molecules in the single crystal. The X-ray analysis shows that the latter alternative is impossible, because from many tests recently carried out in respect to metal structure, we learn that no permanent change in the crystalline lattice is occasioned by stress. The former alternative is also ruled out, because, as Faraday pointed out,[4] bismuth is actually of a lower density after compression than it was before; the pressure having of course been removed. Apparently the breaking up of the specimen increases the extent of the cavities.

Tyndall made many paste models of crystals, mixing powders of bismuth, carbonate of iron, or other active substances with flour and water, or gum. He pressed the mass by different amounts in different directions and then cut it to shape; in this way he imitated the magne-crystallic action in detail. At one time, in order to meet the objection that he was merely rearranging the small crystals in his paste and conglomerates, he took some white wax "concerning whose amorphism there can be but little doubt." The substance is diamagnetic. A little cylinder of the wax suspended in the magnetic field set with its axis equatorial. It was then placed between two stout pieces of glass and squeezed as thin as a sixpence; suspended from its edge, the plate thus formed set so that its length, which coincided with the axis of the previous cylinder, was axial and its shortest dimension equatorial. But we know now that wax is anything but amorphous; its crystalline structure has not only been observed but also accurately measured; and we know also that pressure arranges the orientation of the crystals.

Tyndall obtained the same result with a piece of bread, and we may repeat the experiment. A small piece of the crumb is squeezed between two glass plates, and the edges of the irregular mass are trimmed off, so as to leave a thin disc. When this is suspended so that its plane is vertical, it sets equatorially if the poles are close together and the field is very divergent. It is therefore diamagnetic. But when the bread is moved from the space between the poles to a more uniform part of the field, the plane of the disc turns through a right angle and sets itself parallel to the lines of force. It is quaint to observe how the bread, as it is moved up to the poles, sets itself to pass neatly through the narrow gate and take up a parallel position on the further side. This is due to magne-crystallic action, so that the bread contains crystals, a fact easily verified by X-ray methods.

FIG. 9.—The black lines show different positions of a thin wafer of pressed bread hung by a single fibre. In the outer parts of the magnetic field it sets more or less along the lines, but as it is brought up to the more intense parts, where there is great divergence of the lines, it turns so as to set itself at right angles to the field.

The Effects of Pressure on Crystalline Condition.

The long series of interesting and ingenious experiments which Tyndall made to show that pressure produced proximity and proximity produced the equivalent of magne-crystallic action, must be held to have failed in their original purpose. But they will doubtless be put to a different use.

[4] His reference was to "Gmelin's Handbook of Inorganic Chemistry," vol. 4, p. 428.

They are related to a subject of immense importance in these days, namely, the effects of pressure and tension and mechanical treatment generally, upon the state of a material and upon its physical properties. The consideration of such questions is fundamental to metallurgy and to other industries. The microscope has for many years been employed for the purpose, and the new methods of X-ray analysis are already being put into service. It may well repay us to consider Tyndall's experiments in a new light; and to examine the actual nature of those rearrangements which produced such remarkable changes in magnetic reactions. Tyndall himself discussed the effects of pressure in producing planes of possible cleavage, and was one of the pioneers in showing how such planes, occurring in the earth's crust, were not always to be interpreted as the result of sedimentary deposition, but rather of pressure, which might, if it were exerted more or less along the deposition planes, produce cleavages across the latter. He extended the principle to account for stratification in rolled materials, even in biscuits and pastry!

Faraday's use of lines of force did not, in reality, demand so much framing of hypothesis as Tyndall's polarity. It is to be observed that, as Faraday pointed out, they had no differences about facts, merely about methods of description, which methods, however, were of different value as suggesting development. To Faraday's conceptions have been added theories of magnetism and diamagnetism based on the existence of resistanceless molecular circuits as imagined by Ampère and Weber, or on revolving electrons as explained by Langevin. In the most recent times the quantum theories have again modified our ideas.

Modern Considerations.

The crude hypothesis of the molecular circuit leads simply to a useful point of view of the difference between paramagnetism and diamagnetism, and the most modern discussions, though they differ greatly in appearance, leave that point of view almost untouched. If any of Faraday's lines of force thread a circuit which has no electrical resistance, that number can never be changed. If, therefore, a substance be brought into a magnetic field, the molecular circuits in the atoms of the substance act like obstructions to the lines; and the total obstruction, of which the negative magnetic susceptibility is a measure, is proportional to the sum of the areas of all these circuits, as projected on a plane perpendicular to the lines. It is of no consequence whatever whether there are already currents in those circuits; unless, indeed, the circuits are movable and can alter their set towards the imposed field. Thus the diamagnetism is unaffected by the existence of molecular magnetic fields; or by any changes in them, so long as the total of the projected areas of the circuits is unchanged.

This result does not hold if circuits approach each other so closely that they offer less obstruction to the lines than if they were more separated. Two resistanceless circuits running closely parallel to each other offer little more opposition to the passage of lines than either circuit alone. We should imagine that such changes in the relative position of circuits would only occur in strenuous circumstances such as, possibly, those of crystallisation. It is known that diamagnetic susceptibility may vary very slightly: for example, Oxley has shown that crystallisation sometimes brings about small but definite alterations. As has often been pointed out, this simple theory makes diamagnetism a property of all substances, which can be affected, even overwhelmed, when the circuits already contain currents, and therefore can be orientated afresh by the magnetic field.

Let me say in conclusion that although recently acquired knowledge of the structure of materials leads us to reconsider Tyndall's experimental results, we are still far from the full explanation of the connexion between structure and magnetism, and of the influence of the latter upon physical properties.

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