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CONTENTS

Scottish Chemical Industries

THAT it should become necessary to re-inspire Scotsmen with a belief in their own country seems strange indeed to those who dwell south of the Tweed, where the frequent demonstration of northerly patriotism is received with good-humoured tolerance and not a little pride. Scottish industry, however, is in different case from her highlands or her history, so that it has been thought desirable to enlist voluntary help in the promotion and development of all branches of industry in Scotland, and in that re-inspiration which will lead through confidence to ordered effort and material success. Such a voluntary, non-political, non-trading organisation is the Scottish National Development Council, which was formed in 1931 under the auspices of the Convention of Royal Burghs and the Association of County Councils in Scotland. The Council, which enjoys the patronage of H.R.H. the Prince of Wales and has as president the Earl of Elgin and Kincardine, undertook last year the task of constituting a number of expert technical committees to investigate and report on the present position and tendencies of industry in Scotland; on "the advantages enjoyed and the handicaps borne by Scotland in comparison with England and other competing countries, and to make recommendations for the exploitation of the former and the alleviation of the latter". It was considered important to examine the state of the chemical industry as soon as possible, and a survey of the position in that sphere of national activity has now been published*.

The report opens with a significant phrase. "The chemical industry," it states, "has never been of outstanding importance in Scotland—unless one views it in its widest scope, in which almost every industry is chemical." In the latter assertion lies justification for the insistence with which is advocated, in responsible scientific and industrial quarters, a wider recognition of the fundamental place of chemistry, of course with its correlated sciences, in preparation for industrial careers, particularly in preparation for the tasks which fall to the industrial and political directorate. In these columns the value of chemical science as an educational apparatus, in addition to its obvious claim to a prominent place among vocational subjects, has often been emphasised; once again

* Report of the Committee on the Chemical Industry in Scotland. Scottish National Development Council Economic Series, No. 9 (Glasgow, 39 Elmbank Crescent). 6*d*. net.

we assert that the study of chemistry need not always premise a career at the bench or in the factory, but that it provides a background of rational method and specific information which is of the greatest value in the ramifications of modern industrial and economic life. Such training could not but lead, for example, to a greater appreciation in financial circles of the material benefits to be derived from scientific research properly organised and adequately financed; and to a far more widespread determination, where power already exists, to recruit the 'shock brigades' of research in the van of progressive industry. The report remarks, in fact, that competition with regard to many chemicals is world-wide, and that their manufacture, dependent as this is upon research, highly-skilled control, and the use of large and modern plant, can be carried out only by those organisations which are capable of affording all these requirements.

Taxation and transport are other considerations of prime importance in industrial development. We are reminded that shrinkage of business caused by over-taxation, or by fear of over-taxation, expresses itself in general lack of confidence; this holds up enterprise on the part of existing firms and restrains new firms from setting foot in certain areas. The suggestion is made that districts which have advantages, such for example as reasonable rates, should advertise these and thus attract new ventures. It is surely in the end profitable for rating authorities to make only such demands as, in their informed judgment, will assist local industry and employment to expand and will attract new industries, with their corollaries of greater employment, more local trade, and a longer valuation list. This consideration appears especially pertinent in Scotland in view of the southward drift of industry towards large centres of population, although the existence of cheap rail or sea transport may prove a deciding factor. However, Scotland is well placed geographically for export markets, and the extension of motor transport is encouraging.

It is satisfactory that the report recognises that no useful purpose would be served by endeavouring to favour one portion of Great Britain at the expense of another in defiance of sound economic principles. "The considerations which govern the establishment and growth of an industry are, or should be, purely economic, and any departure from this standpoint is bound to be attended sooner or later with financial disaster." In other words, subsidies of whatever kind are dangerous expedients; the policy which is needed both locally and nationally is that which is based on accurate information, business acumen, courageous expenditure in the continuous acquisition of new knowledge, and the prompt application of such knowledge in overcoming the competition of rivals, whether at home or abroad.

Fermentation industries provide us with an example of potential development which will depend for its fruition on chemical research. The Scottish fermentation industry is, of course, severely handicapped by the extremely heavy excise duties on whisky and beer; moreover, public opinion and consequent legislation tend, and rightly so, to restrict its opportunities for expansion by discouraging the excessive consumption of alcoholic beverages. But alcohol is more than a beverage; it is a source of power and a substance from which numerous organic products may be derived. Therein lies its economic importance. As regards its use as a source of power the Government might well consider the suggestion that a minimum percentage of industrial alcohol should be incorporated in petrol; this action has indeed already been taken by a number of countries which have no indigenous supply of petroleum. So far as alcohol as a synthetic organic chemical is concerned, the report looks forward to the time when "the number of products made from ethyl alcohol and from other compounds obtained by fermentation may be almost as numerous as the progeny of coal tar". Let us hope that our fermentation industries and our agriculturists are fully alive to the implication.

Decline in the shale, textile, and shipbuilding industries in Scotland has affected the heavy chemical industry, which is primarily concerned with the production of raw materials for other manufactures, and tangible development is difficult to foresee. However, Scotland has had a large share of the explosives trade, gaining considerably by amalgamation of those interests. As a producer of leather she is in a relatively poor position, partly because most of the boots and shoes sold in Great Britain are made at Northampton or Leicester, and partly because she is largely dependent on outside sources for raw material. The patent leather industry is not carried on at all north of the Tweed, since in its early days lack of adequate sunlight for hardening the oil film militated against its establishment there; hence we are now dependent on Continental and American

supplies. The bleaching, dyeing, and calico-printing industry suffers from the Indian duties and boycott and from the growth of Japanese competition; "it seems unjust that Japanese goods should be admitted into any Empire markets on the same terms as British goods, while Japan imposes prohibitive tariffs against British goods in all territories under its control". The report on the rubber industry refers to the serious handicap of the tax on petrol and similar 'spirits' consumed in manufacturing operations; in the case of one Scottish concern a duty of 6*d.* per gallon adds £6,000 annually to manufacturing charges.

Iodine continues to be produced in Scotland, considerable quantities being still made from kelp at works in Falkirk and Clydebank, and it is interesting to note that there is one small works in England extracting iodine from kelp. The amount obtained from this source is, of course, only a small proportion of the available supplies, most of which comes from Chile. Again there is heavy competition from Japanese manufacturers who, not being members of the Iodine Convention, sell below Convention rates. Other industries to which reference is made include those concerned with paints and varnishes, cement, chemical plant, barytes, coal, bitumen, wood and bone distillation, pharmaceutical products, food colours and flavourings, bichromate, firebricks, disinfectants, soap, etc.

The pharmaceutical industry regards as necessary such regulations as have been imposed by legislation, but certain other industries complain of obsolete restrictions, while there is frequent reference to the need for cheap transport and amelioration of the burden of taxation. It is suggested that Scottish manufacturers might exploit the goodwill which Scotland is said to enjoy in foreign countries by marking their goods "Made in Scotland". England, which owes so much to Scottish brains and Scottish character, will not begrudge any advantage which this delicate advertisement confers.

Modern Thermodynamics

Modern Thermodynamics by the Methods of Willard Gibbs. By E. A. Guggenheim. Pp. xvi+206. (London: Methuen and Co., Ltd., 1933.) 10*s.* 6*d.* net.

IT is an almost universal experience that thermodynamics is harder to understand than ordinary dynamics. For whatever reason this may be, the consequence is that in the textbooks it has not acquired the same standardised routine of development as has dynamics, but is treated from a great number of different angles. As its title suggests, the present work uses the manner of Gibbs, but it takes advantage of the great advances that were consequent on Gibbs's work to bring the subject up to date. The author has achieved a very high degree of success in his intention, and it is perhaps not too much to say that the book possesses not only the virtues, but also some of the defects of the great classic on which it is based. This criticism is not intended to belittle the book, which has much of the same classical character as its original; a cynic once said that a classic may be a great book, but that it is often one that is too dull to read, and though the saying is inappropriate here, still some readers may feel a faint echo of the sentiment, just as they would in reading its prototype. The resemblance of the two is in many ways very close; thus Gibbs never explains the elementary parts of the subject and nor does Guggenheim, though he is kinder than his predecessor in that he gives references for them to books which make entirely satisfactory introductions.

Having got his basis, the author proceeds in the same leisurely and systematic manner as did Gibbs to develop all its consequences; everything is simple and straightforward, and the only trouble is the same as that which must have assailed many of Gibbs's contemporaries, the feeling: "It is all very nice, but what is a chemical potential anyhow?" In those days this was inevitable as no chemical data existed to illustrate the subject, but in view of the work of G. N. Lewis and others, the matter is very different now and it would have been quite possible to give detailed numerical examples to illustrate all parts of the subject. Granted that to do so would have rather diminished the resemblance of the book to its prototype, yet the departure would have been a material help; and it is surely no part of the tribute of reverence we should pay to a great work to insist that the difficulties under which it was written should be imitated.

As to the details of contents, the book begins with a short account of foundations. The author makes a very just comparison between thermodynamics and dynamics; in dynamics the beginner learns the subject starting with Newton's laws, but for more advanced work a new foundation is made with the help of Least Action. This is usually preferred by the expert, but would be

useless for the beginner, and the present work is to be likened to the more advanced type in dynamics. There is no explanation of entropy; it is regarded as a primitive idea like temperature. This seems an admirable plan, but it is incompletely worked out, since the consequence must be to degrade energy to some less primitive position, for otherwise there would be three primitives instead of the usual two. However, nobody ever agrees about foundations, and the only generalisation about them that holds (and even this will command almost universal dissent) is that though they are things one cannot do without, the exact form of them is a quite unimportant matter of taste.

In the second chapter the author develops all the general differential relations of the subject, and a most attractive feature is that everything is systematically done for all four forms of the thermodynamic potentials, instead of allowing one of the four, the internal energy, to have its usual but unmerited position of privilege. After this, the author proceeds to build up the whole of chemical thermodynamics, starting with systems of a single component, and then treating of gaseous mixtures, and so arriving at his main subject of solutions. These he classifies into ideal, semi-ideal and non-ideal, and the special discussion of the intermediate type will probably be found a most useful simplification of the subject. Making a cross-classification in another chapter, he discusses solutions from the point of view of their diluteness. Altogether, solutions are very fully treated, the original ideas of Gibbs being supplemented by the fruitful conceptions of fugacity, and of activity and osmotic coefficients, which have been brought to the fore by Lewis and others. These conceptions have served to make the dry bones live; our only criticism of their discussion here is that the bones are discussed as they would be in a work on theoretical anatomy, rather than as in one on natural history.

Then there are chapters on electro-chemistry (but not including thermo-electric phenomena), and on surface phases; this last includes not only the thermodynamics of surface tension, etc., but also the quite different subject of such surfaces as grease films on water, which were unknown in Gibbs's day. There follows a very short chapter on radiation, which tells too little or too much, for it gives Stefan's law, but not that of Wien. The final chapter goes outside the field of classical thermodynamics and gives a short account of the so-called third law, and of chemical constants. The author adopts the necessary data from statistical theory, wisely avoiding much explanation, and illustrates the results by good short discussions of many of the substances for which the chemical constant is known; in this particularity he advantageously departs from the rather too abstract method of the purely thermodynamical part of the book.

It will be seen from the above that the book is not to be regarded as an introduction to thermodynamics. It will find its use partly by the mathematical student who wants everything set out in an orderly and systematic manner, and partly by the physical chemist who wishes to see how his more specialised ideas can be fitted into the general scheme. Altogether, it will be found a most useful work of reference for the general theory of chemical thermodynamics. C. G. D.

Richard Trevithick

Richard Trevithick: the Engineer and the Man. By H. W. Dickinson and Arthur Titley. (Trevithick Centenary Commemoration Memorial Volume.) Pp. xvii+290+18 plates. (Cambridge: At the University Press, 1934.) 10*s.* 6*d.* net.

IN William Walker's well-known group of British men of science alive in 1807–8 there is no more romantic figure than that of Richard Trevithick, who at that time was struggling with the problems of steam transport by road, rail and river and was also endeavouring to bore the tunnel known as the Thames Archway beneath the Thames between Limehouse and Rotherhithe. The latter was a project which Trevithick, with that buoyant optimism which was one of his characteristics, had undertaken, thinking "this will be making a thousand pounds very easey, and without any risque of a loss on my side". Entered upon without sufficient preparation and with inadequate appliances the scheme proved a failure, but Trevithick's position as the engineer of the concern had some share in making his name widely known and perhaps had some influence on Walker when choosing his portraits for the group of 1807–8. At any rate, we know to-day how well Trevithick deserved to be placed beside Watt and Telford, Brunel and Maudslay, Davy and Dalton.

The outstanding feature of Trevithick's life-work was his application of the high-pressure steam engine. In this direction he was a great pioneer

and this at a time when the practices of Watt were looked upon by many as the acme of achievement. Trevithick's early life was passed amidst the Cornish mines where Boulton and Watt's low-pressure engines working with steam at 2 or 3 pounds' pressure had saved many a mine from closing down. Boulton and Watt, say the authors of this book, were "the greatest benefactors that Cornish mining has ever had". Where Trevithick got his revolutionary idea of making small compact engines without beams, air pumps and condensers, and circular wrought-iron boilers, using steam up to 50 or 100 pounds' pressure, we do not know, but he had already launched out in this direction before the patent of Boulton and Watt had expired.

It would be a mistake to think of Trevithick as wholly absorbed by his engine work, for he was seldom content with only one iron in the fire and was easily lured aside from the main business of the moment. Yet as can be seen from the chronology given by Messrs. Dickinson and Titley in this admirable 'Life' of Trevithick, the high-pressure engine ran as a connecting thread through his whole career. In 1797 he made models of stationary and locomotive engines, in 1798 he constructed his first high-pressure winding engines, in 1801 his first steam carriage and in 1802, with Vivian, took out his great patent. A year later, in 1803, he made his second steam carriage together with some stationary engines for Wales, in 1804 he constructed the Penydaran rail locomotive, in 1805 the Newcastle locomotive, and these were followed in 1806 by his steam dredger and in 1808 by his locomotive *Catch me who can*. Overtaken by sickness and bankruptcy he then returned to Cornwall, where during the years 1811–1814 he made high-pressure pumping engines, agricultural engines and engines for the Peruvian mines for which low-pressure condensing engines were unsuitable. It was his work for the Peruvian mines which opened to him the prospects of wealth and led him in 1816 to sail for South America. That great adventure, of which we would know more, failed through causes beyond his control, and when eleven years later he returned home, his sole possessions were "the clothes he stood in, a gold watch, a drawing compass, a magnetic compass, and a pair of silver spurs". As always, however, he faced the situation quite undaunted, and to his later years belong those flashes of genius of which the authors write so sympathetically in the sixth and last chapter of their book.

Of Trevithick's upbringing, his environment, his character and abilities, his generosity and want of prudence, his fertility of invention, his thoughtlessness in domestic affairs, his triumphs and his failures, each must read for himself. He was no ordinary man and had some of the attributes of a genius and a hero. Born in Cornwall in 1771, he died in poverty at Dartford in 1833, and last year his centenary was commemorated in a worthy manner. To that commemoration we owe the publication of this book. The Commemoration Committee deciding to publish a memorial volume, Messrs. Dickinson and Titley generously offered their partially completed work and it was accepted. Funds, however, not being forthcoming in sufficient amount to pay for its printing, Messrs. Babcock and Wilcox, Ltd. undertook to bear the cost of publication as their special contribution to the Centenary Fund. In these happy circumstances the book now makes its appearance in a style worthy of the publishers and at a price at which no one can cavil. It is admirably illustrated and besides the chronology and the six chapters dealing with the various stages in Trevithick's career, there are appendices dealing with his memorials, his patents and his descendants. It is certainly one of the best that we know of engineering biographies.

The Werewolf

The Werewolf. By Montague Summers. Pp. xiv + 307 + 8 plates. (London: Kegan Paul and Co., Ltd., 1933.) 15*s*. net.

THERE are various ways of approaching the problem of the occult, as has been shown in the literature on witchcraft which has appeared in the last decade. The fashion of a previous generation which regarded it as a mere superstition of the Dark Ages, happily, has passed away in favour of a more rational attitude such as that of the anthropologist, who seeks to relate the belief to the magical and religious practices of primitive peoples, as an accompaniment of a phase in man's development, or of the psychologist, who seeks to derive an explanation of magical phenomena from mental aberration.

The belief in the werewolf, the 'man-wolf', who puts on an animal form and preys on his fellow men, which was current in medieval Europe and survived down to modern times, is thus regarded either as of a piece with the belief of primitive peoples in the possibility of 'shape-shifting' and, generally, as belonging to their attitude towards

animals as in some way uncanny ; or, alternatively, as based upon misinterpreted observations of perversions, such as necrophany and lycanthropy, or forms of hysteria and delusional insanity, to which the social and economic conditions of the Middle Ages rendered the populace especially prone.

Mr. Summers confines his study of the werewolf to its occurrence in Europe, passing over in a brief reference the werelions, tigers, hyenas and leopards of primitive peoples. He also includes in this class the fox belief of China; strictly speaking, this is not a werewolf belief, but its contrary, for the Chinese fox spirit turns into a man or possesses a human being and not vice versa. Mr. Summers deliberately sets aside the evidence from primitive peoples and he rejects the anthropological point of view in favour of the theological, to which he regards anthropology as merely ancillary. Hence the belief is treated from the angle of Catholic orthodoxy, and apart from chapters dealing with the records of cases of the werewolf in the various European countries, discussion is confined to the opinions and rulings on the subject of the werewolf of writers on witchcraft and magic in the Middle Ages and immediately succeeding centuries. Mr. Summers has an intimate and extensive knowledge of this literature, and his careful analysis and full quotation from the authorities provide a mass of information on this aspect of medieval thought, as well as a useful guide for the use of those who wish to pursue the subject further.

The werewolf in theological argument was regarded as closely allied to the witch ; both were believed to derive their powers from a pact with the devil. As the object of the change of form into a wolf was to prey on human beings and devour their flesh, the werewolf was also closely related to the vampire. Hence it is not surprising to find that the werewolf belief flourished in eastern Europe, the home of the vampire ; and there both beliefs still survive. Russian peasants to-day think that Lenin for a time was a bear. Here they are in agreement with their forerunners, for in the sagas of northern Europe, the animal form assumed was the bear, and the prevalence of the belief is shown by the familiar expression 'berserk'. It is well known that this peculiar relation with the bear still holds among the primitive tribes of northern Asia across to the Far East, where it takes the form of the bear cult, with which the writings of Sir James Frazer have made us familiar. It is unnecessary to look further for an analogy upon which to base a suggested origin for the werewolf type of belief ; but this Mr. Summers would be precluded from admitting as relevant by his theological prepossessions.

Medieval theologicians, not having the advantage of a Sir James Frazer to assist their speculations, were faced with the dilemma of either denying a fact accepted as such by the Church, or supporting an opinion dangerously like a heresy in attributing an act of creation to a power other than God. Their subtle arguments and skilful evasion of the difficulty leave the reader to ponder the nice problem of the conflict between authority and scientific evidence, which Mr. Summers solves by whole-hearted acceptance of the former.

Short Reviews

Wundkompensation, Transplantation und Chimären bei Pflanzen. Von Prof. N. P. Krenke. Übersetzt von Dr. N. Busch. Redigiert von Dr. O. Moritz. (Monographien aus dem Gesamtgebiet der Physiologie der Pflanzen und der Tiere, Band 29.) Pp. xvi+934. (Berlin : Julius Springer, 1933.) 89.80 gold marks.

THIS extensive work first appeared in Russian in 1928 under the title "The Surgery of Plants". The German translation has been edited and brought up to date with the aid of the original author. It is a thorough-going treatment of growth reactions following wounding and the phenomena connected with transplantation and grafting from a causal point of view. Regeneration is considered from every aspect, including chromosome multiplication, hormones and the theory of mitogenetic rays. Many teratological phenomena find here a causal explanation. A considerable amount of modern cytological and genetical work is brought to bear on these problems, and the early but often forgotten work of Darwin is extensively and aptly quoted.

A well-illustrated section of 240 pages deals with the formation and structure of chimæras, a field in which Prof. Krenke has made extensive studies. The whole subject is treated in a way which will throw further light on their nature. The last section deals briefly with the introduction of foreign substances into plants and acquired immunity.

The extensive bibliography includes many Russian papers which might not otherwise be known in other countries. Notwithstanding the usefulness of this work, the price appears inordinately high even although two coloured plates of chimæral *Solanum* fruits are included.

R. R. G.

The Cult of the Goldfish. By T. C. Roughley. Pp. xiii + 146 + 29 plates. (Sydney: Angus and Robertson, Ltd.; London: Australian Book Co., 1933.) 6*s.* net.

MR. ROUGHLEY has written perhaps the best book on gold-fish culture that has yet been published. It is a most useful volume, well produced and full of interest from beginning to end. The author thoroughly understands his fish and shows how they will respond to considerate treatment. Those who read these pages will never wish to keep a gold-fish in a bowl again, but they certainly will wish to keep a real aquarium and care for the fish in it; moreover, directions are given for making the aquarium or pond at home, which must appeal to many craftsmen.

The varieties of gold-fish are numerous and new kinds are constantly appearing. Breeding gold-fish is an exciting occupation and apparently not so very difficult if care be given to essentials. The aquarium made, one is taught how to supply it with suitable plants. The varieties of gold-fish are discussed and their food, also which animals may be put in with them to advantage and which should be avoided. There are chapters on spawning and development, the garden pool, animal pests in ponds and diseases of gold-fish.

Not only are the life-histories of the food animals discussed, but also those of the diseases to which the fish are subject and of those animals which may be found in the pond. Thus the mosquito is useful as the larvæ are a good food, pond beetles and dragonflies are harmful, the larvæ eating the young fishes. The information given on the diseases which so often affect gold-fish is extremely interesting and full remedies are discussed.

Virus Diseases of Plants. By Dr. John Grainger. Pp. viii + 104 + 6 plates. (London: Oxford University Press, 1934.) 6*s.* net.

OUR knowledge of the plant viruses has increased enormously in the last decade. We have not yet, however, arrived at any definite conclusion as to the nature of this interesting group of pathogens. In this book, the whole problem of virus diseases and their etiology is compressed into seventy-five pages, with, in addition, twenty-five pages of bibliography. The first chapter is devoted to a very short account of the general subject. The second deals with the relation of the virus to its host plant—with special reference to some of the better known viruses. It is not quite certain that the suggestions in the section on cytology, that a 1/12 in. oil immersion lens is necessary for the examination of the *X*-bodies and that these bodies frequently disappear by the erosion of the protoplasmic stream, would meet with general acceptance among cytologists. Chap. iii is devoted to the physical and chemical properties of the virus so far as these are known. The fourth chapter deals with the important problem of the insect transmission of the disease and gives some meagre notes on the treatment of insects under experimentation. The chapter on the economic effects and the control of the disease is probably the most useful in the book. It deals with methods for preventing the spread of the disease. The classification and description of virus diseases is dealt with in chap. vi.

This book will be of use mainly as a general account of the plant virus problem.

Celtic Ornament in the British Isles down to A.D. 700. By E. T. Leeds. Pp. xix + 170 + 22 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1933.) 12*s.* 6*d.* net.

IN this study of Celtic ornament, Mr. E. T. Leeds has elaborated a communication presented to the first International Congress of Pre- and Proto-historic Sciences in 1932. It is a survey of the subject as a whole from the earliest appearance of distinctively Celtic art after the coming of the early Iron Age peoples to Britain down to the beginning of Anglo-Saxon times. The various types of characteristic motifs are traced in the finds from initiation to decay and their relations and distributions analysed. Such detailed discussion was eminently desirable, as nothing of a similarly comprehensive nature had been attempted since Romilly Allen's work on Celtic art in pagan and Christian times of more than thirty years ago. In the meantime, not only has the material which Allen had before him come to be more clearly understood, but also much new material has accrued, bringing with it a clearer appreciation of the problems which call for solution. Mr. Leeds's views on the renaissance of Celtic art after the Romano-British eclipse, especially when they differ from those of Mr. T. D. Kendrick, will repay careful consideration.

Neurological Effects of Syphilis: Diagnosis and Treatment. By Dr. B. Buckley Sharp. (Oxford Medical Publications.) Pp. v + 92. (London: Oxford University Press, 1933.) 7*s.* 6*d.* net.

DR. B. BUCKLEY SHARP has provided us with a very interesting book on neurosyphilis; but it might very well have been larger. There are several statements with which we are inclined to find fault. To state categorically that "there are no clinical entities exclusively syphilitic" is a misstatement. There is no better-defined clinical entity than general paralysis, which is in 100 per cent cases exclusively syphilitic. Again, vascular lesions are present in certainly 80 per cent of neurosyphilitics.

The author appears to be prejudiced in favour of including intracisternal salvarsanzed serum in treatment, for he says he and Purves Stewart have never seen a return to a normal fluid without using this treatment. This is not the experience of the majority. The section dealing with diathermy might well have been expanded; a large amount of work has been done on this form of treatment. A 2 gm. dose of tryparsamide is just as satisfactory as 3 gm. and much safer.

The Drinking Habits of Birds

By SETON GORDON

THE lover of birds who places a shallow dish of fresh water each morning beside the bird table and has the pleasure of seeing chaffinches, robins and other of his bird friends drink eagerly from it, may perhaps have wondered how young birds in the nest receive the moisture which is necessary to them, or how sea-birds drink.

I do not think that the young of any British birds actually drink in the nest; they receive their moisture in the food which is brought them, and it is partly no doubt because they cannot drink that the parents are so careful to shield them from the direct rays of the sun before they are feathered. It is not perhaps generally known that direct sunlight is fatal to young birds. The gannet is one of the hardiest birds, yet I have known a young gannet succumb after being left unattended in the nest for the space of rather more than an hour while the strong August sun beat down upon its small, black, naked body. Even the golden eagle, which leaves its eaglets unprotected to the snow-laden wind, builds its eyrie almost always where the nest faces north and thus is sheltered from the sun. During a recent early summer, my wife and I watched almost daily for the space of a fortnight at an eagle's eyrie from a heather hide. The eyrie was facing north-east, and the sun did not shine on it after eleven o'clock in the morning. One morning after a very cold spell the sun shone strongly on the eyrie. The morning had been dull and close, and when the sun, shortly after half past ten, suddenly emerged from one of the heavy clouds, its rays were brilliant and for once I felt comfortably warm in my hiding-place. The mother eagle was standing at the edge of the eyrie, and when the sun appeared walked over to the eaglet (which was three weeks' old and covered with thick white down) and, standing between it and the sun, slightly opened her great wings to shelter it. The sun increased in power, and gradually, in three distinct movements, she spread her wings to their fullest extent and stood quite motionless. The beauty of that picture I shall long remember. My peep-hole was not more than twelve feet from the nest, and every feather of the eagle was distinct, the great wing primaries drooping to the sides of the eyrie. The sun gradually left the eyrie and when the nest was in shade the eagle folded her wings, walked to the edge of the eyrie and launched herself on the air with a sudden splendid gesture.

The young golden eagle is hatched early in May and does not take its first flight until mid-July. During all that time it never drinks, but depends for its moisture on the food brought to it—hares and grouse, rabbits, even stoats and squirrels. But does the adult eagle drink? Some observers believe that it never does so, but a stalker told me that he once came suddenly on a golden eagle bathing, if not actually drinking, in a clean pool of a hill burn, and in his words "when she had finished bathing herself she walked to the edge of the pool and shook out her feathers just like an old hen".

There may be quite a number of our land birds which do not habitually drink, and what of the great army of sea-birds that live their whole lives on the salt water? Do they drink sea-water? Or do they never drink? I do not refer to the sea-gulls, which spend a part of their time on land, but to the vast armies of guillemots which crowd the rock stacks in summer as they incubate their eggs on arid sunbaked ledges, to the colonies of razorbills, cormorants and shags, to the storm-loving petrels and the gannets which fly tirelessly a hundred miles and more to catch a fish for the hungry family. The only water which all these birds know is the salt water of the ocean. Do they drink it or does their fishy food, saturated with moisture, supply them with liquid enough? Even if they do not drink salt-water, they must have some means of dealing with their food, which is salt-impregnated, and would probably be fatal to a land bird. All who know the great northern diver, the guillemot, the black guillemot and other divers of the sea must be familiar with the habit of all these birds of dipping the bill constantly into the water after a dive and also when swimming. This is done whether the bird has caught a fish and swallowed it, or whether the dive has been unsuccessful, so that it cannot be to clean the bill. The impression given superficially is that the bird is drinking, but I am rather inclined to believe that it is a habit, perhaps originally adopted when cleaning the bill. It is interesting to note that when human inquirers approach a nesting place of a pair of black guillemots the birds swim rapidly backwards and forwards, calling shrilly and repeatedly dipping their bills in the water.

There is one exception to this habit of bill-dipping among the divers of the sea. The puffin does not dip the bill, although it is as assiduous a fisher as any. Perhaps it is because its bill, being large and clumsy, would offer too great a resistance to the water through which the bird is swimming. It can, I think, be safely concluded that this curious habit of holding the bill just beneath the surface of the sea while swimming has nothing to do with drinking.

Sea-gulls, although they pass much of their time on the sea, leave it when they wish to bathe and drink. There is one small loch beside the Atlantic where gulls are almost always to be seen bathing with relish, and they fly backwards and forwards between this loch and the sea, perhaps several times a day.

The wild whooper swan which arrives in Britain in autumn from Iceland settles at times on the sea, but is never happy on the salt water, although its relative, the smaller Bewick's swan, passes most of the winter season on the brackish lochs and estuaries of the Hebrides. Ducks appear to drink frequently, but wild geese at their winter haunts must be able to go some time without water, for some of the sea-girt isles where they live have no fresh water upon them.

The grey or hooded crow is detested by game preservers because of its habit of stealing eggs. Especially when the grey crows have young in the nest they hunt far and wide for the eggs, not only of grouse but also of much larger birds, and I have known them suck a nest of a grey lag goose's eggs in a single day. It is possible that this egg stealing is partly to provide the young birds in the nest with as much liquid food as possible, and one can understand why young hooded crows should be able to exist without water. But the twite, which feeds its young on seeds, the siskin, the linnet and other passerine birds—how is it possible that the broods of these birds should live without water during their time in the nest? The passerine birds which feed their young on hard and dry seeds do so by regurgitation. They swallow the seeds, and later present them to their young moistened, and impregnated with their digestive saliva. Those which feed their young on insects and other juicy living food feed them directly, without regurgitation.

Dr. Glover Allen, in his book "Birds and their Attributes" referring to the drinking habits of North American birds, writes:

"In the far north water may be unobtainable throughout winter, but it may be possible for northern birds to subsist on snow. I have known pine siskins to eat snow and once watched a flock of Cedar Waxwings engaged in catching snowflakes during a storm, flying up and snapping at them as if they were insects. Here is a subject on which more information might easily be secured."

Elsewhere Dr. Allen remarks:

"A final word as to the drinking habits of birds, which have not perhaps been sufficiently studied. We have all noticed that hens and sparrows sip from a pan, raising their head between each sip as if to let the drop trickle down their throats. The quite different manner in which pigeons thrust in their bills and pump in the water like a horse cannot have escaped the attention of most. We do not know much as to the amount of water birds need and how often they drink. It is said that prospectors in desert country are often able to locate springs by watching the flights of doves or pigeons which must drink daily and fly in from the surrounding country regularly for the purpose.

"Most sea birds are known to drink salt water in preference to fresh; indeed captive gulls may die without it. Land birds, however, need fresh water. No doubt some species must go long periods without drinking, as in case of certain birds that incubate continuously, for example, the female Hornbill that is walled up in her nest cavity and fed by her mate."

In "Jungle Side", a natural history account of Ceylon, by John Still, are some interesting remarks on the drinking habits of birds. The author writes:

". . . the lovely paradise fly-catcher who nests in some garden in the nor'-east monsoon can be found passing the sou'-west as a visitor to a water-hole. Others are permanent forest dwellers, like the wonderful long-tailed robin whose song is the sweetest in all Ceylon, and another rather rare little bird who often owns a water-hole to himself, the three-toed kingfisher, whose gay habit it is to have rosy plumage where most of his tribe have blue."

Observations by trained watchers on the drinking habits of birds are, however, very meagre, and the whole fascinating subject would certainly repay more close observations.

Joachim Barrande and his Palæontological Work

By JAN KOLIHA, Curator of the Barrandeum, National Museum, Prague

A LITTLE more than fifty years ago, on October 5, 1883, the death occurred of Joachim Barrande, who was one of the greatest palæontologists of the second half of the nineteenth century. Barrande was born on August 10, 1799, on the estate of his family at Sangues (Dept. Haute Loire). He studied at the Paris Polytechnic School. Besides lectures of a purely technical nature on bridge- and road-construction, he attended those on geology, zoology and botany. His teachers were G. Cuvier, A. Brongniart, de Jussieu, C. Prévost, de Blainville, G. St. Hilaire, Serres, Audouin and others.

Soon after Barrande left the Polytechnic, he was called to the French Court, to act as tutor in natural science and mathematics to the hereditary Prince Henri, Count Chambord, grandson of Charles X. When the Bourbon family was expelled from France, after the revolution of July 1830, Barrande also went into exile with them. After a short stay in Edinburgh, the royal family came to Bohemia, first of all living at Buštěhrad Castle (west of Prague) and then at the Castle, Prague (that is, Hradčany, the old royal castle of the Czech kings). From this time onwards, Barrande remained permanently in Prague.

In 1833 Barrande gave up his position as a tutor, and devoted himself to engineering. He was entrusted with the surveying of a projected line, which was a continuation of the horse route, from Křivoklát, along the River Berounka, to the coal basin of Radnice and then on to Plzeň.

During this work, Barrande found a number of beautifully preserved fossils, in Middle Cambrian shales, in the neighbourhood of Skryj and of Tejřovice. By these discoveries he confirmed his view, that strata exist in Bohemia similar to those which Murchison had studied in Wales and Scotland. When the first part of the latter's "Silurian System" appeared in 1839, Barrande decided to investigate systematically all the so-called Transition Strata and their fauna in Bohemia, being certain that the Silurian formation of Bohemia was the same as that in Britain.

Finally, after many years of investigation and collection, Barrande began the publication of his "Système silurien de la Bohème" (1852), a work which even to-day is the only one of its kind in palæontological bibliography. The author published between 1852 and 1881 twenty-two big quarto volumes, partly containing text, partly plates. The treatise contains more than 6,000 pages of descriptions and 1,160 plates of fossils. The first volume, in which he deals with trilobites, forms, together with the supplementary parts, the most important and best account of these extinct crustaceans in general. Barrande also gives a careful description and illustration of the geological conditions in the older Palæozoic rocks of Bohemia. He divides the "Silurian" into eight series, indicated by the letters A to H. He determines the order of succession, the relations of deposit, and the fossiliferous contents of all his stages, based on their palæontological connexion with the British Silurian. In this and in the following volumes of his work, the author describes in turn the other crustaceans besides trilobites, and the fishes, cephalopods, brachiopods and lamellibranchs known up to that time in Bohemia.

It is clear from his palæontological work that Barrande was a convinced believer in the constancy of species (being a pupil of Baron Cuvier), and therefore an opponent of the theory of evolution. It is well known that his objections were among the most weighty of those which were ever expressed against that theory.

While issuing his chief work and several lesser publications, Barrande spent much time in defending his theory of so-called 'colonies', which were supposed to be intercalations of parts of a later geological fauna in strata containing an older geological fauna, the result of migrations. Barrande, from 1861 until 1881, was at war with many well-known geologists, and to the day of his death was never shaken in his opinion of such migrations of faunas. He defended his view by the publication of polemical articles, letters and longer works, which were gathered into five parts and entitled "Défense des Colonies". The chief opponents of Barrande's views were Prof. J. Krejčí, the father of Bohemian geology, V. M. Lipold, the Viennese geologist, and J. E. Marr, the English geologist, who explained these phenomena as due to faulting of the strata.

Barrande also took part victoriously in the dispute concerning the independence of the so-called Taconic System in North America, ending a discussion of many years by proving that the fauna which was discovered by Emmons and Marcou represented his primordial Cambrian fauna.

Meanwhile, great uncertainty prevailed both in the Bohemian National Museum and in the Czech University as to what would be the fate of the huge collections of fossils made by Barrande. Various negotiations took place, letters were written to Barrande, and a promise was obtained that his collections would be installed in the new building of the National Museum. When Barrande's will was opened, it was discovered that the National Museum had become the heir of all his collections, of all his manuscripts, and of his scientific library. By this splendid bequest, the National Museum of Prague has become the owner of one of the greatest collections of older Palæozoic fossils, and as such is the most important goal of all geologists and palæontologists who study the oldest fossiliferous rocks.

Obituary

Prof. Sven Odén

IT was with the deepest regret that we heard of the death of Sven Odén. He had for some time been in failing health, but his friends still clung to the hope that his vigorous vitality might win. Unfortunately this was not to be, and he died on January 16 in his forty-seventh year.

Odén was trained under Svedberg and was soon recognised as an exceptionally able colloid chemist. His first investigation, published in 1910, was on the coagulation of colloidal sulphur, and it brought out the important fact that small variations in the hydrogen ion concentration of the solution greatly influenced the critical concentrations of electrolytes that just brought about coagulation. This group of problems interested him throughout the whole of his life and he constantly reverted to it. In 1911 he began an important series of investigations on the size of the particles in the suspension, determining the mass of the particles lying between successive size limits. This led him to a study of fractional coagulation. All this work he pursued with great ingenuity, using as his materials such varied substances as clays, deep sea deposits, cements and various precipitated substances. Having an unusually wide outlook, he was able to apply his results not only to problems in the pure science of colloids, but also to problems of applied science.

Nothing better illustrates the genius of Odén for attacking a difficult problem than the automatic balance he made for use in sedimentation investigations. By its means he was able for the first time to construct curves showing the mass

distribution of particles between any desired limits of size in a mixture of various sizes. Readers in Great Britain are familiar with some of these curves, especially those in his paper in the *Proceedings of the Royal Society of Edinburgh* in 1911 on the size of the particles in deep sea deposits, and in the *Proceedings of the Royal Society* of 1924 when, along with a group of Rothamsted workers, his colleagues during a period of extended leave spent at Rothamsted in 1923, he developed more fully this automatic balance and worked out typical distribution curves for clay particles of different sizes. The subject is discussed fully in Dr. B. A. Keen's monograph, "Physical Properties of the Soil". Later work at Rothamsted showed certain unforeseen sources of error not yet overcome which detract from the strict quantitative interpretation of the results. Whether they can be avoided or not, the work stands out as the first and best study of distribution of clay particles according to size.

A second group of investigations in which Odén achieved marked success dealt with peat. He began about 1916, and by 1919 was able to publish his monograph "Die Huminsäuren", one of the best that has ever appeared on that particularly difficult and elusive group of mixtures. Applying for the first time the methods of modern physical chemistry to the black sticky mixture of humus substances soluble in alkalis and reprecipitated by acids, he gave for the first time definite proof that the so-called humic acid really is an acid and he was able to assign to it fairly definite properties including tentative molecular and equivalent weights. Considerable discussion has followed, and there has been in consequence of his work much clearing up of a very involved subject. In addition to these physico-chemical investigations he also studied the possibilities of obtaining fertilisers by the use of peat: its use as a source of ammonium chloride and for rendering mineral phosphates soluble.

Another investigation in organic chemistry made by Odén, in conjunction with E. Fischer, was the synthesis and study of sugar derivatives having molecular weights ranging up to 8,000.

Up to this time Odén had been working at Uppsala, first (from 1913) as lecturer in chemistry; and later, in 1920, as professor of inorganic chemistry at the Technical Institute of Engineering. In 1925 he became head of the Chemical Department of the Central Experimental Agricultural Station, Experimentalfältet, which post he held until his death. Here he turned his attention to the exchangeable bases in the soil, which he studied by electrodialysis. His last papers were on the application of electric light to the furtherance of plant growth, and the relations of certain organic compounds and the growing plant.

Odén was not only a brilliant investigator but also a delightfully human personality, a man one loved to meet and talk to; full of ideas, overflowing with energy and vitality. Whatever he touched he illuminated, and the more difficult the subject the more it attracted him and stimulated his inventive powers. Sweden has lost a distinguished son and science a brilliant worker.

E. J. RUSSELL.

DR. LILIAN CLARKE

THE death of Dr. Lilian Jane Clarke, at the age of sixty-eight years, marks the passing of the pioneer of the best modern methods of the teaching of botany and Nature study in schools. The subject early attracted her and having gained the gold medal of the Apothecaries' Society for botany and entered University College, London, in the session 1887–88, she took her B.Sc. degree in 1893–94, after studying botany under Prof. F. W. Oliver. She was appointed science mistress at James Allen's Girls' School, Dulwich, in January 1896, and from that time onwards devoted herself whole-heartedly to developing her own ideas of botanical teaching.

The 'laboratory' Dr. Clarke found in 1896 at James Allen's was a tray of apparatus on the hall platform; the laboratory she left was a well-equipped building for botany and other scientific subjects, with a greenhouse for biological experiments, and a large area of land laid out in the botanical gardens for which the school is justly famous, and with which Dr. Clarke's name will always be associated. These gardens started with a few natural order beds, but as her method of direct teaching of Nature study was developed, more land was gradually acquired for the study of plant physiology and ecology. At first the financial difficulty was great, but eventually the value of the gardens was recognised by a small grant which permitted further extensions. The work throughout was done almost entirely by the voluntary labour of the school pupils in their spare time, and with their aid Dr. Clarke built up a range of gardens unparalleled elsewhere. Order beds, plots for genetical and physiological experiments, shingle bank, bog garden, pond, a lane with its hedgerows and even an oak wood were all finally acquired, and provide a wealth of material for teaching purposes. The value of her pioneer work in this direction was recognised in 1902 by the award of the degree of D.Sc.(Lond.), and in 1905 she was one of the first women admitted as a fellow of the Linnean Society.

Somewhat of a martinet in her laboratories, Dr. Clarke instilled habits of carefulness and accurate working into her pupils, which many of us have since fully appreciated. The secret of her success was unbounded enthusiasm and driving power, coupled with the ability of interesting individual students in particular details of the work, making even the drudgery appear worth while. Compulsory retirement under the age limit went sorely against the grain, but to the end she maintained her interest in the work of James Allen's School and of many of her old students, whose careers she followed closely.

As secretary in 1921–26 of the Education Section of the British Association Dr. Clarke did further work for the improvement of teaching methods ; she was also chairman of the committee on the teaching of general science in schools, with special reference to the teaching of biology.

Apart from her botanical work, Dr. Clarke had a wide knowledge, and love for, Old London, and only two years ago she founded the London Wanderers Club among old J.A.G.S. girls, herself acting as leader on periodical rambles, sparing no time and trouble in their successful organisation. The esteem in which she was held by her old students was marked last year by the foundation of a "Lilian Clarke" botany prize fund at James Allen's School, and no more fitting tribute to her memory could be raised than an extension of this fund for the further encouragement of the subject for which her life was spent. Her affection was fixed on Dulwich, and by her special request the first part of the funeral service was held in the old College Chapel, in the presence of the upper school and her friends and colleagues.

WINIFRED E. BRENCHLEY.

MR. R. J. MOSS

THROUGH the death on January 27 of Mr. R. J. Moss at the age of eighty-seven years, the Irish scientific world has lost one of its last links with the brilliant period of which FitzGerald was the leading spirit. Moss was appointed keeper of the minerals and analyst to the Royal Dublin Society in 1875, and registrar in 1878, a position which he held until his retirement in 1921. He was the oldest member of the Royal Irish Academy, having been elected in 1874.

Despite his onerous routine duties, Moss published many original papers, chiefly on chemical subjects. Among these may be mentioned those on cobalt chloride as a moisture test, on an improved method of determining the gases dissolved in water, and on the state in which helium exists in pitchblende. In the last he employed an ingenious method of extracting the helium by grinding the mineral *in vacuo*. He also investigated some archæological problems. His last paper, read before the Royal Irish Academy in 1926, deals with a chemical examination of some ancient metallurgical crucibles. From his analyses he arrived at important conclusions as to the metallurgical knowledge of the ancient Irish.

Moss, however, like so many scientific men of his period, did not restrict his work entirely to one branch of science. His earliest work, carried out in collaboration with H. N. Draper, dealt with the photoconductivity of the allotropic forms of selenium. He published papers on the spheroidal state and in 1896 investigated the effect of X-rays on the combination of hydrogen and chlorine and on the fluorescence of various salts.

It is perhaps for his work in the foundation of the Irish Radium Institute that he will be longest remembered. When Joly first proposed his method of using radon in fine glass capillaries for therapeutic purposes, Moss designed and constructed the requisite apparatus. In this his skill as a glass-blower and his knowledge of handling small quantities of the rare gases were a great asset. The original apparatus was used for many years at the Institute. During the War he, and his two assistants Messrs. Stone and Deane, carried out all the work of the Institute, and large quantities of radon were supplied to various military hospitals, mainly for the treatment of wound scars.

To those who knew Moss only in his later years, one of his most striking characteristics was the extreme ease with which he carried their burden. To the last he was a valued member of the Irish Radium Institute Committee and a regular attendant at scientific meetings. Of him, I think, we can use, in its best sense, the saying : He, whom the gods love, dies young.

J. H. J. POOLE.

PROF. T. ERIC PEET

WE regret to record the death on February 22 at the age of fifty-two years of Thomas Eric Peet, reader in Egyptology in the University of Oxford.

Eric Peet was educated at Merchant Taylors' School, of which in later life he became a governor, and at Queen's College, Oxford, where he was Jodrell scholar and graduated with second class honours in Classical Moderations and *Literæ Humaniores*. In 1906 he was awarded a Craven fellowship and entered the British School of Archæology in Rome, later holding the Pelham studentship. The results of his researches were published in 1909 in "The Stone and Bronze Ages in Italy and Sicily", a book which is still recognised as a standard authority.

Peet then turned his attention to Egyptology ; and this remained his principal occupation for the rest of his life. He excavated in Egypt at Abydos, at first under Prof. Garstang and then as assistant to Prof. Naville, on behalf of the Egypt Exploration Fund, collaborating in vols. 1–2 of the valuable memoirs on the cemeteries of that site. He also collaborated in a publication on the inscriptions of Sinai. A work entitled "Rough Stone Monuments and their Builders" appeared in 1912. In the following year Peet was appointed lecturer in Egyptology in the University of Manchester.

After the War, in which Peet served with the King's (Liverpool) Regiment in Salonika and France, he resumed excavation in Egypt on behalf of the Fund at El-Amarna, publishing "The City of Akhenaton", vol. 1 in 1923. His "Egypt and the Old Testament", a book of more general appeal than his other works, had appeared in 1922, and in the meantime he had also devoted attention to the study of papyri, more particularly those of a mathematical character, the result appearing in publications issued from 1920 onwards, dealing with the Rhind, Mayer and other papyri. On Prof. P. E. Newberry's retirement from the

Brunton professorship in the University of Liverpool in 1923, Peet was appointed to succeed him, and in the same year was elected Laycock student of Egyptology of Worcester College, Oxford. From that time onward Peet ceased to take an active part in field work, but devoted himself to teaching and research, also editing the *Annals of Archæology and Anthropology* (Liverpool) and the *Journal of the Egypt Exploration Society*. His "The Egyptian Dynasty" appeared in 1930 and his Schweich Lectures, on "Comparative Study of the Literatures of Egypt, Palestine and Mesopotamia", in 1931. On the retirement of Prof. F. Ll. Griffith from the chair of Egyptology at Oxford last year, Peet was appointed as reader; being also elected to a fellowship by his own college.

At the very outset of his career, Peet was recognised as a brilliant archæologist, and at no time did his performance fall below expectation.

WE regret to announce the following deaths:

Dr. F. A. Bather, F.R.S., formerly keeper of the Department of Geology, British Museum (Natural History), on March 20, aged seventy-one years.

Prof. Davidson Black, F.R.S., professor of anatomy in Peiping Union Medical College and honorary director of the Cenozoic Research Laboratory, National Geological Survey of China, on March 15, aged forty-nine years.

Prof. F. Ll. Griffith, emeritus professor of Egyptology in the University of Oxford, on March 14, aged seventy-one years.

Dr. Walter Rosenhain, F.R.S., formerly superintendent of the Department of Metallurgy and Metallurgical Chemistry in the National Physical Laboratory, on March 17, aged fifty-eight years.

News and Views

Liquid Crystals

WE are publishing as a special supplement this week an account by Sir William Bragg, director of the laboratories of the Royal Institution, of those substances which in Great Britain are usually called 'liquid crystals'. Their very striking appearances on the microscope stage are fairly well known; but this is the first time that a coherent story has been made of the optical principles by which their characteristic behaviour is exhibited. The authors of even the most modern books on optics have not given this matter their attention; and until recently only superficial notice had been taken in Great Britain of this class of substance. The examination and explanation of their behaviour links them on one hand to the large class of oriented liquid films, and suggests on the other hand that more regular structure which X-ray analysis is daily revealing to us in so many directions. By means of new photographs, diagrams and drawings of models, Sir William Bragg has with appealing directness given us a statement of the problems which these bodies have yielded. The optical behaviour of the main groups is thus seen to be related to a varying degree of regularity of arrangement while in the mobile phase. Sir William's article, which gives a clear picture of the subject without going greatly into detail, will provide a stimulus to the growing interest which Friedel's 'mesomorphs' are attracting among physicists and others in Great Britain.

Sir Robert Greig

SIR ROBERT GREIG, Secretary of the Department of Agriculture for Scotland, is about to retire from that position, as he attains his sixtieth year on March 23. He has only held the post for about five years, but that has been long enough for him to prove himself an excellent chief who has backed all scientific development in his Department. After leaving the University of Edinburgh, Sir Robert was for a time a ranch manager in north-west Canada. After returning to England he was for two years lecturer at the Cheshire Agricultural College, passing on for four years to the Durham College of Science. In 1903–10 he was the Fordyce lecturer in agriculture at the University of Aberdeen. In 1911 he returned south to become staff inspector in agriculture at the Board of Education, but not for long, for in the same year he became a commissioner at the Board of Agriculture, Scotland, of which body he was chairman in 1921–28. The combination of technical knowledge and administrative ability exemplified by Sir Robert goes far to explain his success; and general regret is expressed at his impending retirement.

Technical Officers and Administrative Posts

ON or about the same date that Sir Robert Greig retires, one of the four assistant secretaries of the Scottish Agriculture Department is also due to retire, in the person of Mr. H. M. Conacher. It may almost be assumed that their successors will be Scotsmen, or there would be 'wigs on the green' at Westminster. It is to be hoped also that on this occasion full consideration will be given to the claims of technical officers in Government departments to be selected for these posts, instead of assuming, as is usually done, that they cannot be capable administrators. The functions of the Scottish Department of Agriculture are of a character which render technical knowledge and experience, in addition to administrative ability, highly desirable qualifications for the controlling posts. The Department's work is largely concerned with the scientific development of agriculture, the organisation of agricultural education, and the carrying out of schemes of land settlement. For these purposes it employs a variety of technical experts, and it is not too much to ask that senior members of these technical staffs should definitely be brought under review in the filling of the impending vacancies in the controlling posts.

Rothamsted Experimental Station

ROTHAMSTED must surely have appeared to most of its scientific visitors as the embodiment of stability, and it has come as a great shock to learn that its historic fields are threatened by the builder. When Lawes in 1889 set up the trust that governs the Station, he did not give the classical experimental fields or the land on which the laboratories stand, but only the use of them for a period of years. After his death it was found impossible to work the experiments without taking on the Home Farm from the family trustees, and this was done in 1911; but some of the highly important fields were let to Rothamsted on a six-monthly arrangement only. Even so, the farm remained awkward and difficult to work, being split into three separate pieces, easy access to which was possible only by courtesy of the estate and the tenant. With the encroachment of the builder a new situation has arisen. The family is proposing to give up possession and to put the whole estate into the market. The situation has been closely examined by the Lawes Agricultural Trust Committee in consultation with the staff of the Ministry of Agriculture, and the conclusion has been reached that Rothamsted must own the land on which it is working. An appeal for £30,000 has therefore been issued over the signatures of an influential group including the Duke of Devonshire; the presidents of the Royal Society, the Royal Agricultural Society, and the National Farmers Union; Lord Clinton, the chairman of the Rothamsted Committee; Sir Daniel Hall, the late director and Sir John Russell, the present director of Rothamsted.

IT is greatly to be hoped that the appeal may succeed. The sum required is not large having regard to the area of land involved (515 acres) and to the fact that the purchase includes also Rothamsted Manor House, a Jacobean mansion, without which, it is understood, the land could not be acquired. Rothamsted has a record of more than ninety years to its credit; its first triumph was the discovery of the value to agriculture of artificial fertilisers, and of the way to make them on the large scale; it was on the Rothamsted fields that they were first tried on the large scale, with the result that the fertiliser manufacturing industry in various countries now has an annual output of some 35–40 million tons. It is not, however, because of past triumphs that Rothamsted deserves to survive. With a staff of some sixty scientific workers, it is an active centre of research on agriculture, soils, fertilisers, plant nutrition, statistical methods in biological science, plant pathology, entomology, and bees, while from its laboratories there has gone forth a steady stream of young men and women to take up high posts in practically all the more important agricultural research institutions in the Empire. Further, agricultural experts from all parts of the world go to work in its laboratories, to study its methods and its results. Its essential characteristics are the spirit of co-operation between the various departments which greatly facilitates border-land work, and the close connexion between field and laboratory, which it is now hoped to put on to a permanently secure basis.

Mr. H. Dennis Taylor

THE council of the Physical Society has awarded the eleventh Duddell Medal to Mr. Harold Dennis Taylor. This medal is given "to persons who have contributed to the advancement of knowledge by the invention or design of scientific instruments, or by the discovery of materials used in their construction". Mr. Taylor has lived and worked in a period which must always be regarded as of the first importance in the development of optical instruments. The work of Abbe and Schott may be said to mark the beginning of the modern period in lens construction. At this time, Dennis Taylor was the optical manager of Thomas Cooke and Sons, of York, a firm celebrated for its astronomical and surveying instruments. Large astronomical refractors of that period suffered from a serious defect, the so-called secondary spectrum, a residual defect remaining when the normal conditions for the removal of chromatic aberrations have been satisfied. Taylor removed this defect by employing three glasses, and with rare skill and insight devised an objective in which not only the purely optical problem was solved, but also the important practical problems of giving accuracy of form to large lenses of different shapes, and allowing for their deformation in use. In these first triple apochromats, the colour correction is so good, and is so successfully combined with the other fine corrections needed, that the same instruments may be used both for visual and for photographic work. A number of large telescopes of this type are in regular use, among them two, of apertures 12½ in. and 12 in., at Cambridge; other 12 in. instruments of this design are in use at Rio de Janeiro and at Kodaikanal in India.

IN 1893 Mr. Taylor took out two patents for photographic lenses, which were later put on the market as the well-known Cooke lenses. In the specifications of these lenses, nothing is more striking than the treatment of the theory which leads to the method of eliminating coma simultaneously with curvature and astigmatism. In later years Mr. Taylor has not lost the skill and originality he displayed in his earlier inventions. Many of these fall outside the field in which physicists are specially interested. Mention should, however, be made of the telescope in which he showed that it is possible to combine a large aperture and a large field of view with freedom from aberrations comparable with that attained in the Cooke lenses. This is undoubtedly an achievement of the first order, and may prove of great value in scientific work. Mr. Taylor has not only made outstanding advances in the construction of lenses, but he has also written a systematic treatise, "A System of Applied Optics", which will enable the physicist of the future to understand the scientific basis on which the art of lens designing rests.

Major John Wesley Powell, 1834–1902

THE centenary occurs on March 24 of the birth of Major John Wesley Powell, the distinguished American explorer, geologist and ethnologist. Born

at Mount Morris, New York, of English parents who had emigrated to the United States in 1830, Powell was educated at Illinois and Oberlin College. He served in the army during the Civil War, losing an arm at the battle of Shiloh, and in 1865 became professor of geology in the Illinois Wesleyan University at Bloomington. Two years later he began a series of hazardous and important expeditions to the Rocky Mountains and the Green and Colorado Rivers, which led to a Government geographical and geological survey of the Rockies. Powell served on this for several years and his reports, together with those of F. V. Hayden and G. M. Wheeler, were embodied by Clarence King in the United States Geological Survey bulletins. In 1879 Powell was made director of the United States Bureau of Ethnology, and in 1881, on the resignation of King, he became also director of the Geological Survey. He held the latter post for thirteen years, but retained the former until his death at Haven, Maine, on September 23, 1902. Powell was one of those pioneer geologists of the Far West, who as von Zittel said, "by their vivid portrayal of the work of subaerial denudation . . . roused the intellectual life of the middle of the century to new conceptions on a grand scale".

The Electron in Electrical Engineering

MR. C. C. PATERSON gave on March 15 the Faraday lecture to the Institution of Electrical Engineers, choosing as his subject "The Electrical Engineer and the Free Electron". It was the kind of lecture that one could have imagined Faraday himself to have given, consisting of lucid explanations and practical demonstrations of fundamental principles. Mr. Paterson stated that the science of electrical engineering was born again when the physicist showed how electricity could be liberated from metal. In the free state it has potentialities of which no one dreamed before its discovery by Sir J. J. Thomson. Just as physiologists learned that disease can be envisaged in terms of isolated germs and their life-history, so the physicist found that electricity can be thought of in terms of the individual electron, its habits and affinities. Two of the main reasons for the practical usefulness of electricity are the ease with which it can be transported and the ease with which it can be controlled. In the latter respect the free electron has now given the engineer new and extraordinary power. Many applications have been already revolutionised and there are doubtless many more surprises in the future. The secret is that a stream of free electrons, whether in a vacuum or a gas, can be manipulated with such facility that the electrical energy output can be reversed at the rate of millions of times a second. Alternatively, it can be made to fluctuate at any given slow speed. While the agency which imposes this control on the electron stream is usually itself electrical, it is possible to control it by light, magnetism or heat.

NORMALLY the electrons are confined within metal conductors. When a portion of a circuit (a thermionic valve cathode or filament) is heated, electrons emerge freely, like water pouring through a porous section of hose pipe. Heat is the agent which liberates the electrons from the interior of the wire. They swarm in a thin layer round the outside surface, ready to be attracted away by externally applied electrical forces exerted by another metal electrode. As the electrons travel between the electrodes, the control causes them to flow or ebb, reverse or oscillate. Frequencies up to 3,000 million per second are attainable. The photoelectric cell is another liberator of electrons. In this case they emerge from a sensitised cold surface (cathode) where light falls on it, and are collected on the anode. These cells are capable of receiving more than 300,000 impulses per second. Mr. Paterson explained and demonstrated the way in which sound and speech are reproduced in various devices. He said that the electron often behaves as if it were a solid particle, but under other conditions it appears to be a group of waves. It acts the same whether it has the particle or the wave characteristics. In free space it acts like waves, but when it collides with something it has particle characteristics. The filament of the incandescent lamp causes the electrons to crowd together and this heats it so much that it gives out light. If the electrons escape from the filament its light-giving properties deteriorate, but if the gas envelope is filled with suitable gas mixtures, the escaping electrons collide with the gas atoms and produce a brilliant and highly efficient light source. This is the principle utilised in luminous gas discharge tubes. Cold cathode tubes need a high voltage to induce the electron stream, but a hot cathode produces a much more copious stream and enhances the brightness of the light. Some of these luminous tubes produce twice as much light as an ordinary filament lamp taking the same power.

Excavations at Ur

OWING to the late date at which excavations were resumed at Ur this year, Dr. C. L. Woolley's first report on the season's work has only just been received and is published in the *Times* of March 16. The operations of the joint expedition this year are to be directed to the exploration of a cemetery of the Jemdet Nasr period of about 4,000 B.C., which lies at a depth of 54 ft. below the surface and involves the removal of about 5,000 tons of accumulated rubbish. The three weeks' work which had been completed at the time Dr. Woolley wrote has produced a remarkable example of sculpture in the round in the form of a woman's figure in alabaster with lapis lazuli inlay forming a fillet outlining the face, lapis lazuli and shell eyes, bituminous inlay for the eyebrows, which meet above the nose, and hair in dark paint. The statue is ten inches high. It is not only the earliest known example of sculpture in the round at Ur, dating from about the last quarter of the fourth millennium, but it is also remarkable as being the first statue to be found in a grave. It lay in a soldier's grave, close to his head and touching the blade of a bronze axe which he carried over his shoulder. This grave is situated in what would appear to have been a military cemetery in the latter

half of the Royal Cemetery period. This at least is the inference which Dr. Woolley draws from the number of battle axes, adze-shaped axes and daggers which have been found in this area. An interesting feature in the economy of the city is conjectured to interpret the existence in the very heart of the town of an area which throughout the history of Ur was a mere rubbish heap. A section shows that while this rubbish heap was continually receiving additions, it was at the same time constantly being removed to provide material for the terraces on which new buildings were erected.

Early Art at Giza

AN interesting account of the excavations of the Egyptian University at Giza during the present season is given by the Cairo correspondent of the *Observer* in the issue of March 18. The expedition, of which Prof. Selim Hassan is in charge, is engaged in investigating the Fourth Pyramid, with its surroundings, which has been identified as that of Khunt Kawas, daughter of Menkaura of the Fourth Dynasty. The exploration of the city attached to the pyramid, the only one of its kind yet discovered, has been carried further and has resulted in bringing to light, among other discoveries, the source of the water supply of the libation chamber and above the libation tank the tomb of an official described as "the purifier and prophet of the king's daughter". The temple of Khunt Kawas has been located adjoining the temple of Menkaura and has been cleared. The most notable of the finds here are the base of a diorite statue of the king Chephren, grandfather of the princess, and the torso of a sphinx and the body of a statuette of the king which lay in the entrance to the temple of the king. In a temple of Ankhtef, the priest of the king's *Ka*, were found two small white limestone statues which are said to be the most perfect examples of the statuesque art of the early period. They represent Ankhtef himself seated and a woman kneeling and kneading bread, which, it is thought, may possibly represent his wife. An almost equally notable specimen of this early art is the statue of a judge of the period, which shows remarkable power in the modelling of the muscles and limbs.

Empire Marketing Board Research Commitments

WITH the abolition last year of the Empire Marketing Board, considerable anxiety was felt as to the provision for numerous investigations, in progress and projected, hitherto financed by the Board. Some weeks ago, Mr. J. H. Thomas stated in a written reply to a question in the House of Commons that provision was being made for such investigations (NATURE, Feb. 17, p. 254). In reply to a question by Sir Arnold Wilson asking for more specific information, Mr. Malcolm MacDonald has given the following written answer: "The research schemes financed from the Empire Marketing Fund comprise agricultural and scientific research in the United Kingdom and also in the Dominions, India and the Colonies. It has been arranged for 39 of these schemes, representing an annual cost of approximately £200,000 in all, to be continued, in each case at the same research institution and with the existing personnel. Of these schemes 23 are in the United Kingdom, eight in the Dominions and India and eight in the Colonies. The sum of approximately £115,000 which is required in the next financial year from United Kingdom funds in respect of these schemes will be charged against Votes administered by various Government Departments in this country. The remaining £85,000 is being met by the Governments of the Empire or by the institutions or industries concerned."

Research Under the Agricultural Marketing Boards

IN a written reply to a question by Sir Arnold Wilson in the House of Commons as to what extent the powers conferred by both Agricultural Marketing Acts to adopt schemes for research in the production and marketing of agricultural products have been exercised by the Potato, Bacon, Milk, Pigs, and Hops Marketing Boards, Mr. Walter Elliot, Minister of Agriculture, stated: "The Hops Marketing Board does not possess any powers of the kind referred to. The other Agricultural Marketing Boards mentioned have certain powers which they may exercise in connection with research services, but I understand they have not yet exercised them." Mr. Elliot said he had no doubt that the Boards in question will give attention to the question of research at the earliest possible opportunity, and that they will approach the Ministry of Agriculture should they think the Ministry able to assist them.

Wool Industries Research Association

THE report of the Council of the Wool Industries Research Association for 1933–34 refers to a 40 per cent increase in fees for private investigations as indication of the growing use which is made of the services of the Association by its members. Income from trade subscriptions has slightly increased, but an income of about £2,000 a year from the Empire Marketing Board has ceased. The activities previously financed by the Board are being continued and efforts are being made to obtain assistance from the Imperial Agricultural Bureaux. At a meeting of the Executive Council of the latter, it was emphasised that the work of the Association at Torridon should be concentrated on investigations of practical value to the grower and to the industrialist, and that Torridon should become a centre from which work on wool utilisation—both as regards research and educational publicity for the Empire as a whole—should emanate. Experiments on the nutritional influences on wool growth have continued in co-operation with the Rowett Research Institute, Aberdeen, and have revealed accentuated differences between a group of sheep fed on a maintenance ration and one receiving a simple supplement of high energy value. Arrangements have been made for further trials of experimental wool packs, including the impregnation of jute packs with rubber latex to anchor the jute fibres so that they do not stray into the wool during transit.

(*Continued on p.* 457.)

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Liquid Crystals*

By Sir William Bragg, O.M., K.B.E., F.R.S.

THERE are substances which are liquid in their mobility and crystalline in their optical behaviour. The latter property suggests that there must be some degree of arrangement of the component molecules, and the former that this arrangement is readily disturbed though it may be as readily renewed. Such substances are generally described as 'liquid crystals'. It is argued, especially by Friedel, to whom we owe so much of our knowledge of their properties, that the title is bad, because the substances are neither perfect crystals nor perfect liquids. Friedel would call them mesomorphs, which is much more logical, since the conditions to be described are intermediate between other conditions that are well known. The term 'liquid crystals' is, however, simple and suggestive, and those who use it are not likely to be misled.

The first to give any full and clear account of the properties of liquid crystals was O. Lehmann[1]. Following him, a number of investigators have attacked the general problem from various sides, Vorländer, Schenck, Friedel, Grandjean, Mauguin, Oseen and others. Quite a large literature has grown up round the subject. Friedel has given a full account of his experiments in the *Annales de Physique*[2]. The present state of knowledge may be inferred from the account of the general discussion on liquid crystals and anisotropic melts held by the Faraday Society in April, 1933[3].

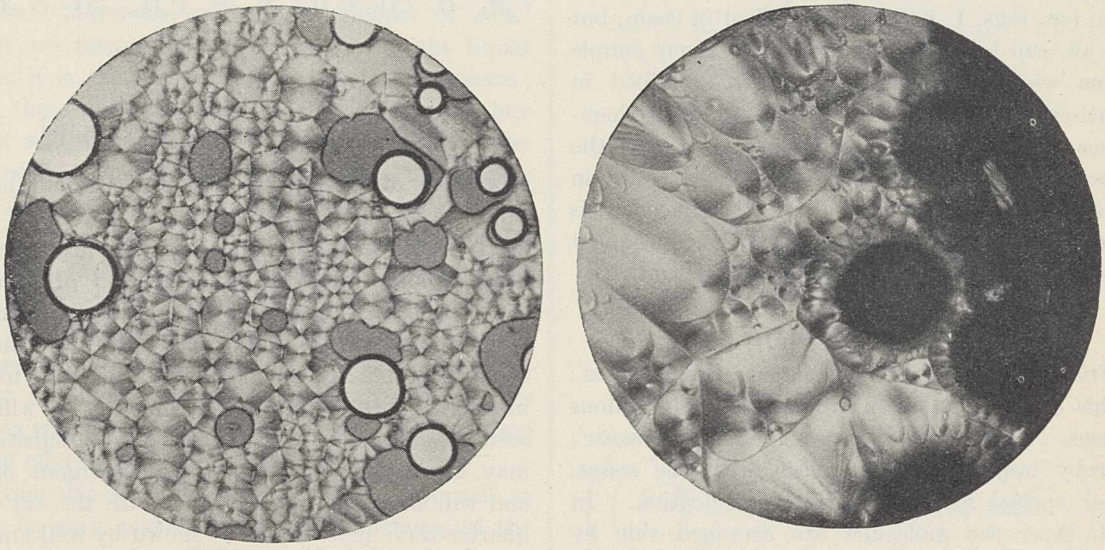


Fig. 1.—Enlarged photomicrograph of a liquid crystal. A Nicol prism is used as analyser ; there is no polariser. The substance is ethyl *para*-azoxybenzoate, temperature 114°–120° C. Notice the polygons and the appearances of cones within them. The white circles are air-bubbles : the grey portions are liquid. The diameter of the original before magnification is 0·075 cm.

The characteristic properties of liquid crystals are connected with the peculiar form of their molecules. These are relatively complicated structures possessing a common feature in their lengthy, chain-like form. It is not surprising that such molecules should sometimes exist in a state intermediate between solid and fluid. If the form and influences of a molecule can be represented approximately by a sphere, an assemblage of such molecules will resolve itself into individuals at some definite temperature. That is because all the links with neighbouring molecules are similar and break down together. But when the molecule is relatively long and narrow, the linkages in

* From the Friday evening discourse delivered at the Royal Institution on November 24, 1933.

different parts of it may be of different strengths. Some may be broken at a lower temperature than others. There must then be one or more intermediate states of greater but not complete mobility. A sufficiently high temperature will bring about the dissolution of the remaining molecular associations, and then a truly liquid state is reached. Though the intermediate phases lack the complete ordering of the crystal, that which remains has necessarily its optical effects.

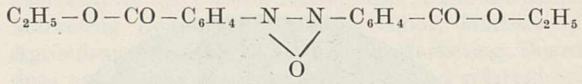
It is an important fact that the changes from solid to liquid crystal, and from liquid crystal to liquid, are as sharp and definite as the change from solid to liquid in the more general case.

These optical effects possess in many cases a singular beauty, in respect both to colour and to form (*see* Figs. 1, 12 and 13*). Most of them, but not all, can be explained in comparatively simple terms which, however, are rarely described in treatises on optics. Writers have confined themselves to true crystals and true liquids, and the more complicated problem is discussed only in isolated papers. In what follows a brief account is given of this peculiar optics and of the consequent inferences as to the liquid crystal structure.

Smectic Crystals

Friedel divides liquid crystals into three classes : in his own words, there are three mesomorphous phases. The first of these he calls 'smectic', thereby implying a parallelism with the soaps. Their special feature is their stratification. In each layer the molecules are arranged side by side, like corn in a field, the thickness of the layer being the length of the molecules. In the case of the soap bubble or film, we have such layers forming the surface inside and out. The side to side attractions of the molecules bind them together, so that the film has a certain surface energy of tension. If the film is made to grow larger in extent, other molecules of the sodium oleate slip into their places and increase the area. If the film contracts, molecules drop out and go back into the liquid.

Let us suppose now that such layers are formed in the substance ethyl azoxybenzoate, which shows the smectic phenomena very well. Each sheet is very flexible. If such a sheet could be suspended in space, free from gravity, it would take the form of a perfectly flat surface because the molecules would tend to lie parallel to one another. Their side to side attractions are relatively strong. If bent, it would straighten itself out again. If a number of such sheets were put together like the leaves of a book, they would tend to adjust themselves further, so that the ends of the molecules on the face of one sheet fitted exactly in some characteristic way on to the ends of the molecules on the next sheet. In this way the solid crystal would be formed, in which there is arrangement and regular repetition in every direction in space. But in the smectic state the temperature is high enough to ease the bonds between sheet and sheet, and yet not high enough to break up the sheets themselves. A single sheet does not necessarily behave like a separate crystal : it is rather to be considered as a two-dimensional fluid.



Ethyl *para*-azoxybenzoate
Solid −114° −smectic −120° −liquid.

A sheet of this nature can slide without hindrance on its neighbours. When a film of the above-mentioned substance is stretched over a small hole in a plate, the condition of parallel layers is in fact arrived at. It can also be reached when the substance rests on a plate, but unless the plate is carefully prepared it is apt to be interfered with by local attachments, as will be seen presently. In the simple form the substance may be examined in polarised convergent light, and will show the usual rings. With the aid of a quarter-wave plate it can be shown by well-known methods that the arrangement simulates a positive crystal. The full structure of the crystal is not realised because the separate sheets are not properly adjusted to each other. That, however, does not affect the examination in convergent light, which requires only that the axis of the beam shall be perpendicular to the layers. The experiment shows that the substance behaves like a positive crystal, such as quartz. In other words, the frequency of the light vibrations perpendicular to the layers (and parallel to the molecules) is less than the frequency when the vibrations are not perpendicular thereto. This is to be expected, because it is always found that vibrations along an extended molecule are slower than those across it.

The simple stratification lends itself also to study by X-rays, when it appears that the thickness of the layer agrees closely with what we know of the length of such molecules, based on exact X-ray measurements of other organic molecules. Friedel[4]

* The photographs are due to Mr. W. J. Green.

gives the value 19·9 A. In the solid crystal the thickness of the layer is found to be 16·2 A. The difference is due to the fact that in the layers of the solid the molecules are inclined and not upright as in the liquid crystal.

In general, however, the substance, when placed between glasses, as is usual when examination is to be made under the microscope, and when raised to the proper range of temperature, or cooled from the melt, does not assume the simple form. The strata are crumpled. Attachments between substance and glass are strong, and at various points these attachments compel the arrangement of the molecules in different directions. The general arrangement has to accommodate itself to enforced conditions in various places. Moreover, nuclear associations of molecules are formed at various points in the liquid when it is passing into the liquid crystals phase ; and these must be fitted to one another as they grow and meet together. There is something like the contortion of strata in a geological formation ; but the smectic arrangement is simpler, because the layers, while preserving their thickness exactly, can slide easily over one another and so can adjust themselves to surface conditions.

The optical peculiarities of the smectic state are caused by these contortions of the strata. We have therefore to consider in the first place the forms which the strata assume, and in the second their effect upon the transmission of light.

From direct observation it can be inferred, as will be seen presently, that the surfaces of the strata form series of the 'cyclides' examined long ago by Dupin and known by his name. We must therefore consider their chief properties.

The locus of the vertices of the circular cones (cones of revolution) passing through a given ellipse is a hyperbola which passes through the focus of the ellipse and lies in a plane perpendicular to that of the ellipse. Conversely, the ellipse is the locus of the vertices of circular cones passing through the hyperbola. The ellipse and the hyperbola are described as 'focal conics'.

Surfaces can be drawn which are at right angles to all the straight lines which pass through both conics. These are Dupin's cyclides. They are peculiar in that any pair of surfaces is equally separated everywhere, the distance of separation being measured along the common normal. Obviously this makes it possible for the surfaces to coincide with the surfaces of sheets of uniform thickness.

It is easy to form an idea of the arrangement by considering a simple case. The ellipse may become a circle, in which case the hyperbola becomes the axis of the circle, that is to say, a straight line passing through the centre of the circle and perpendicular to its plane. The cyclides become 'anchor rings' or 'tores', intersected at right angles by every straight line that meets both circle and axis. The construction is shown in Figs. 2 and 3.

When this simple case occurs in the liquid crystal, the strata are bounded by a succession of anchor rings equally separated. The straight

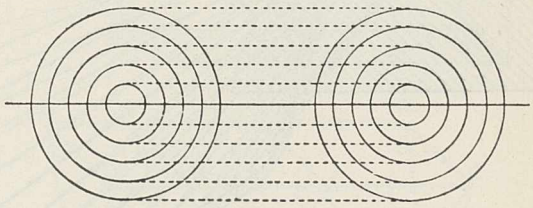


FIG. 2.—Section of an anchor-ring in layers, which constitute a particular series of Dupin's cyclides.

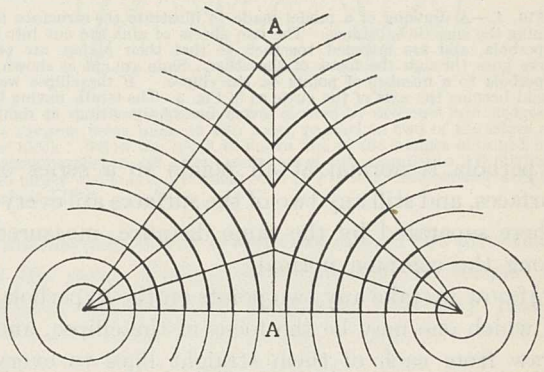


FIG. 3.—An axis AA is now added to the ring of Fig. 2. Every straight line drawn from any point on AA to any point on the axial circle of the ring meets every layer at right angles. In this figure emphasis is laid on those parts of the layers which lie within the cone of which the upper point A is the vertex and the axial circle is the circumference of the flat base. Within the cone the layers are in equilibrium with each other. How one cone can be fitted to another is explained in the text.

lines that meet both circle and axis are perpendicular to the strata and therefore parallel to the long dimension of the molecule. As has been said above, the substance behaves like a uniaxial crystal, the axis lying along the molecule. The straight lines show therefore the direction of the optic axis at every point, being parallel to the molecules round about the point. It must not be supposed, however, that each such straight line is a chain of molecules ; if that were the case converging lines of molecules would 'jam' into one another.

It will be observed that no two of the straight lines intersect. We may pass from this special

case to the general by imagining the circle to become an ellipse and the cones to be pushed over to the side as in Figs. 4 and 5. The anchor rings become distorted, but the characteristic properties of the cyclides are still maintained. Every straight line that meets both ellipse and

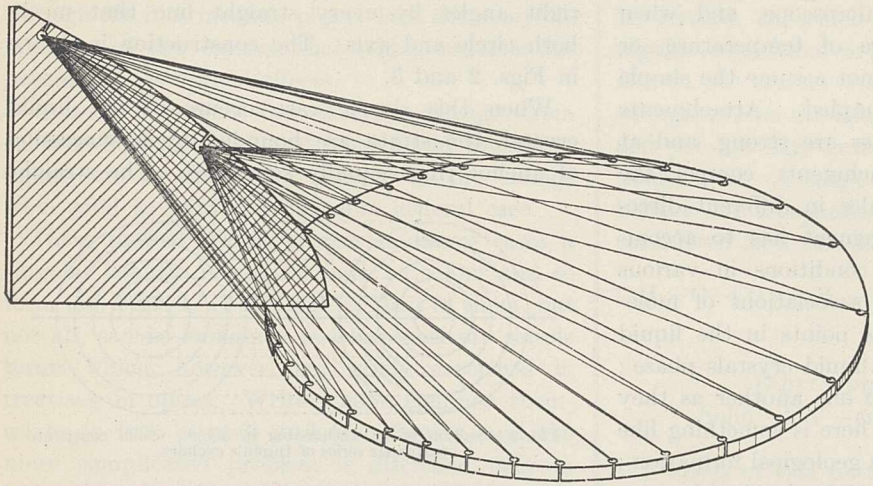


FIG. 4.—A drawing of a model made to illustrate the structure of the interior of an oblique cone containing the smectic substance. The two sheets of zinc are cut into the form of an ellipse and part of a hyperbola, and are fastened together so that their planes are perpendicular to each other and each curve goes through the focus of the other. Slots are cut as shown, and strings join two points on the hyperbola to a number of points on the ellipse. If the ellipse were made into a circle, the hyperbola would become the axis of the circle as in Fig. 3. The strata, having the form of Dupin's cyclides, intersect every one of the strings at right angles.

hyperbola is normal at all points to a series of surfaces, and still any two of the surfaces are everywhere separated by the same distance, measured along the common normal.

If now we take any two points on the hyperbola, of which one may be the focus of the ellipse, and draw from each of them straight lines to every point on the ellipse, we include a region bounded by two cones, or in the special case one cone and its flat base, which can be divided by Dupin cyclides into a series of sheets of uniform thickness; and at all points on the surface of the space the sheets are perpendicular to the generators of the cones.

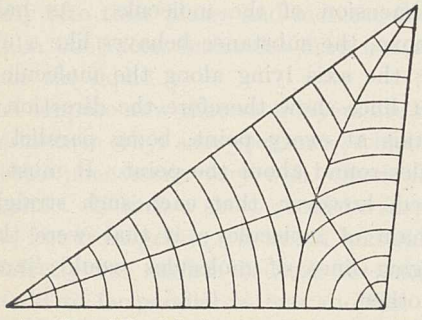


FIG. 5.—A section of Fig. 4 in the plane of the hyperbola, showing parts of cyclides. Compare this with Fig. 3. The complete cyclide which in Fig. 3 was a uniform ring, the so-called 'anchor ring', is now thicker on one side than on the other.

We are now going to see how, in imagination, we can divide a solid mass of material, such as that which lies on the microscope slide, into separate blocks, in each of which the substance is arranged on one or more sets of cyclides, while all the blocks can be fitted together so that the stratification runs continuously through the whole.

If two such conical regions are made to touch along a common generator, the cyclides in one region may be looked on as continuations of the cyclides in the other, though they come into contact only at the common generator. Any pyramidal space can be divided into cones, large ones in the centre, smaller cones partially filling up corners that are left, and still smaller cones filling up corners that are still left, and so on. The pyramidal space can then be further sub-divided into strata of uniform thickness by sets of cyclides, one set to each cone, which all fit on to one another, and meet at right angles the straight lines drawn from the vertex to all the points on the polygon forming the base. In each of the cones the vertex and the focus of the ellipse forming its base are the two terminal points on the hyperbola belonging to that cone. Since all the hyperbolæ lie on planes that are perpendicular to the bases of the cones, which bases are co-planar, and all pass through the vertex of the pyramid, the major axes of the ellipses all pass through the projection of the vertex on the basal plane.

A solid block can be divided into two sets of pyramids, half of which have their bases on each one of two opposite faces and vertices on the other, together with certain wedge-like spaces. This is readily seen if we consider such a division as is indicated in Fig. 6, where the pyramids are, for simplicity, set on square bases; and it appears that besides the pyramids there are wedges or tetrahedra such as *IJPQ*. Pyramids and wedges account for the whole. Now the top and bottom edges of each wedge can be looked on as portions of a pair of focal conics, and the

space inside the wedge can be divided by cyclides which meet the other four edges at right angles and therefore pass continuously into cyclides in the adjoining pyramids. The top and bottom edges must have at least some small curvature. If straight lines be drawn from every point on the upper edge to every point on the lower, they are all normal to the set of cyclides which divide the space inside the wedge into layers of uniform thickness. Thus the whole of a solid block can be divided into uniformly thick contorted layers by Dupin cyclides belonging to a number of different sets which, however, fit on to each other perfectly.

We have next to show that the optical effects are consistent with such an arrangement, and in fact establish its existence.

In a solid crystal the direction of the axes is constant throughout. In a liquid crystal this is not the case. Fortunately for our convenience in solving the new problem, there is only one axial direction at each point, namely, that which is perpendicular to the layer; it coincides with the straight line passing through the point and also through the two focal conics. We may divide into two parts the problem of the path of a ray through a liquid crystal. Consider first the case when a continuous change in the direction of the crystal axis is taking place in the plane containing the path of the ray. Let that plane be the plane of the paper and let the axes be directed towards the point O in Fig. 7. Clearly a vibration which is perpendicular to the plane is always perpendicular to the axis wherever it is, and is never deflected. But a vibration in the plane of the diagram is that of an 'extraordinary' ray and suffers continuous deflection. Its path was calculated by Grandjean[5] who showed that it moves on the curve $r \cos n\alpha = a$, where r and α are polar co-ordinates, O being the pole; n is the ratio of the refractive index of the extraordinary to that of the ordinary ray, and a $(=OA)$ is a constant. If $n=1$, the curve becomes a straight line, as it ought to do, since the substance would then behave as if isotropic, and a ray of light would go straight through. The curve in the figure has the two straight lines OP and OQ as asymptotes, and the angle $POQ=\pi/n$. An extraordinary ray approaching along a line originally parallel to OP but not directed at O is finally deflected along OQ. At the beginning and the end it is very nearly an ordinary ray. To sum up, ordinary rays consisting of vibrations normal to the diagram suffer no deflection, but extraordinary rays do.

Next we consider a ray passing through a region where the direction of the axis is changing

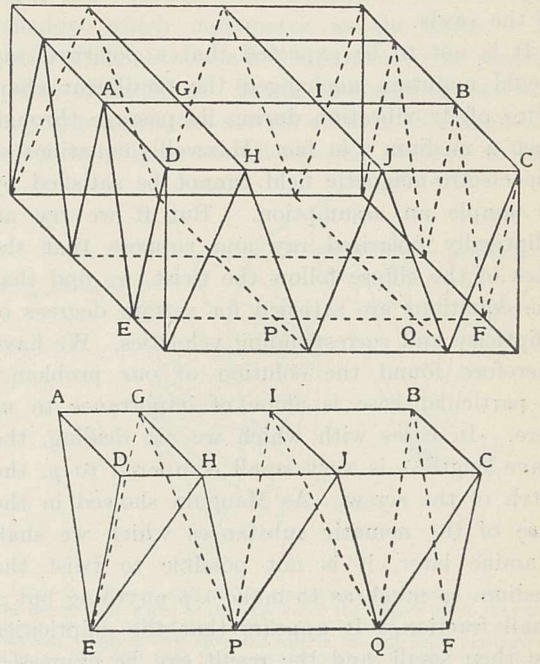


FIG. 6.—The rectangular block is divided by saw-cuts into wedges; the division being made in two ways, parallel to two of the edges of the block. Below the block is shown one of the wedges obtained by cutting parallel to AB. The second set of cuts, parallel to AD, divides this larger wedge into pyramids such as $P(GHIJ)$ and smaller wedges such as $IJPQ$.

continuously but is always normal to the direction of the ray. Such a structure may be termed a twisted or helicoidal structure. In any plane

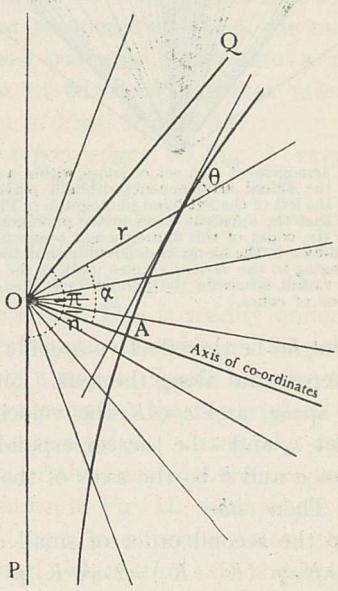


FIG. 7.—The curved line shows the path of the extraordinary ray in a medium in which the axial direction at any point is directed towards O. The axes and the path lie in one plane.

which is normal to the ray, the direction of the axis is the same at every point but the direction changes continuously along the ray, as happens in a pack of cards to which a twist has been applied about an axis perpendicular to the plane of the cards.

It is not to be expected that a polarised ray would maintain unchanged the rectilinear character of its vibration during its passage through such a medium ; in fact, Maxwell's equations of the electro-magnetic field cannot be satisfied by so simple an assumption. But if we try an elliptically polarised ray and suppose that the axes of the ellipse follow the twist, we find that the equations are satisfied for certain degrees of ellipticity and corresponding velocities. We have therefore found the solution of our problem.* A particular case is alone of importance to us here. In cases with which we are dealing, the wave-length λ is very small compared to p, the pitch of the screw. As Mauguin showed in the case of the nematic substances which we shall examine later, it is not possible to twist the medium so much as to make λ/p anything but a small fraction. It appears that the ellipticities are then small, and the result can be expressed as follows :—

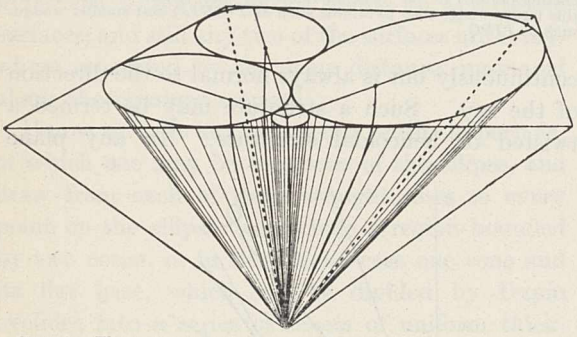


FIG. 8.—The arrangement of a set of cones within a pyramid. It follows closely the actual arrangement within a polygon near the bottom and on the left of the left hand photograph in Fig. 1. It is to be remembered that the apparent cones in the photographs of Figs. 1 and 12 are not the cones of this figure though connected with them. Some lines are drawn in the figure in order to outline the cones. The hyperbolæ belonging to the various ellipses meet at the vertex of the pyramid. The vacant spaces in the pyramid are filled with smaller cones or portions of cones.

Let K_1 and K_2 be the effective specific inductive capacities across and along the axis. Let c be the velocity in space, and $c/\sqrt{K}$ the velocity in the medium : let λ_0 and λ be the corresponding wave lengths. Let a and b be the axes of the elliptical vibration. Then *either* :—

$K=K_1$ to the second order of small quantities and $b/a=2\lambda K_1/p\ (K_1-K_2)=2\lambda_0\sqrt{K_1}/p\ (K_1-K_2)$ *or* $K=K_2$ and $a/b=2\lambda_0\sqrt{K_2}/p\ (K_2-K_1)$.

* A short proof is given in *Proc. Roy. Inst.*, **28**, 90 ; 1934.

It appears therefore that in the twisted medium two elliptical vibrations can travel without change of form, each with its special velocity. When the twist is small we may assume that incident light is resolved into two linear vibrations, the ellipticity being negligible. These vibrations, however, follow the twist, so that the vibrations at any point are always along and perpendicular respectively to

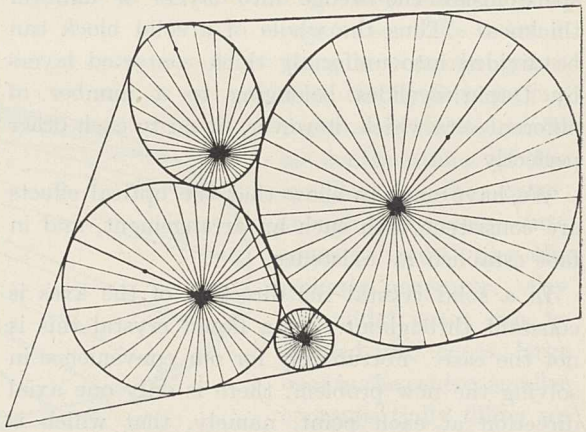


FIG. 9.—This shows the base of the pyramid in Fig. 8 : and the axial directions radiating from every focus at the base of the hyperbolæ (see Fig. 8). The axes of the ellipses all meet at a point which is the projection of the vertex of the pyramid upon the base.

the crystal axis at that point. If exactness were necessary, we should have to recognise that incident light is always resolved into two elliptic vibrations of different ellipticities travelling with different speeds. For example, a polarised ray, in which the vibration is parallel to the crystal axis at the surface, is resolved into two elliptic vibrations which travel at different rates. The major axis of the larger lies in the direction of the incident vibration, that of the smaller is perpendicular to it and is equal to the minor axis of the larger. The two rotate in opposite directions. At regularly spaced depths in the medium the two again combine into a linear vibration.

It is to be observed that this effect is practically independent of the wave-length. The rate of rotation for all wave-lengths is that of the mechanical structure.

Any axial direction can be brought into coincidence with any other axial direction by a rotation in the plane containing the direction of the ray combined with a rotation about the ray. Thus we are able to say, as the result of the two cases considered, that the ordinary ray goes through the liquid crystal without any change in the direction of its path, no matter how the axis of the crystal alters its direction, provided that

the latter alteration is continuous. The direction of the vibration changes in such a way that it is always perpendicular to the axis of the crystal. On the other hand, the extraordinary ray, though behaving like the ordinary ray in all other respects, continuously changes the direction of its path when there is any continuous change in the orientation of the crystal axis, which has a component in the plane containing the ray and the axis.

We can now proceed to examine the appearance of a smectic substance in the light of what we have just proved. Let us consider the photographs in Fig. 1. These are typical of the great variety of appearances presented by a thin layer of ethyl azoxybenzoate. It is in the smectic state, the temperature being held between the limits 114°C. and 120°C. The microscope is focused on the upper surface of the layer and is viewed through an analysing Nicol. There is no polariser. We observe at once the assemblage of polygons each with its content of ellipses. If we suppose that the substance is crumpled up into a combination of sets of cyclides as explained above, and also that these are grouped in cones, pyramids and wedges (see Figs. 4, 5, 6, 8 and 9) then the arrangement of the optic axes in the surface of the layer will be as in Fig. 9; with infinite possibility of variation in the number and sizes of the ellipses. The molecules on the surface lie always on straight lines, which show the directions of the crystal axes at every point, and in each ellipse radiate from the focus to the circumference.

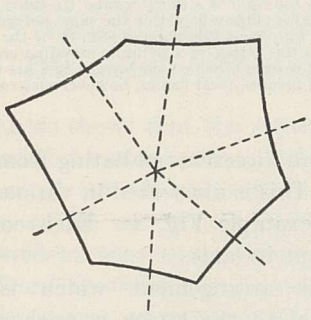


FIG. 10.—This shows the disposition of polygon edges in one face of the lower left hand portion of Fig. 12 with respect to polygon edges in the other face.

At every point the vibration in the ordinary ray as it emerges is perpendicular to the radius vector from the focus. The original beam divides into two on entering the substance, as usual, but the extraordinary ray quickly goes astray. If it gets through, its vibration is inclined to the radius vector, but its appearance is quite irregular. On the other hand, the ordinary ray appears uniformly at all parts of the field and gives the clear picture which is seen in the microscope. The analyser transmits vibrations parallel to its principal plane, and consequently each ellipse is crossed by a shadow which culminates at the focus. The central line of the shadow is parallel to the principal plane of the Nicol. It will be observed that when a polygon includes several ellipses, the major axes of those ellipses are all directed towards a single

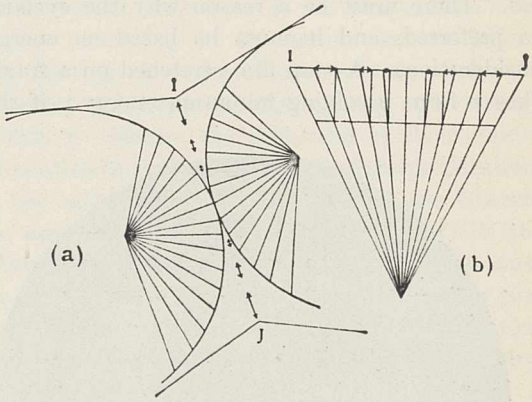


FIG. 11.—This shows how the crystal axes in the edge of the wedge *IJ* are at right angles to the axes inside the ellipses where they touch the edge (*a*). About the middle of the edge, the axes are often vertical. This is very often the case in the left hand illustration in Fig. 1. The light from below gets through on this line without being resolved, and is only half darkened by the analyser. The section of *IJ* marked off by arrow-heads represents the direction and relative values of the axial projection on *IJ*; the manner of doing this is shown in (*b*).

point, which, as already explained, is the projection upon the polygon of the vertex of the pyramid standing on the polygon. The vertex lies on the opposite face. When the microscope is adjusted so that the lower face is in focus, it is found that the point on which the major axes of the ellipses converge melts into a point where a number of edges of polygons meet. This is illustrated in Figs. 10 and 12.

The polygon edges of Fig. 1 vary in shade, some being light and some dark. It will be observed that the dark edges are more or less parallel to the middle line of the shadow in each polygon; and therefore also to the crystal axis along the edge. This is readily understood when we remember that the side of the polygon is the top edge of a wedge. Inside a wedge the axes run from every point on the top edge to every point on the bottom edge. Along the top edge the projection of the axes is therefore parallel to the edge as shown in Fig. 11. Somewhere in the edge, however, there is a point, unless the wedge is very skewed, where the axis is perpendicular to it, being the shortest distance between the top and bottom edges. At this point the extraordinary

becomes equivalent to the ordinary ray. There is no separation when the light enters the medium, and the analyser does not quench it entirely. A black edge then shows a white spot in the middle.

From the general and close agreement between theory and observation, we may surely conclude that the smectic substance is indeed arranged in strata which take the form of Dupin's cyclides. There are, however, any number of other geometrical arrangements of sheets of uniform thickness. There must be a reason why the cyclides are preferred, and it must be based on energy considerations. A soap film stretched on a frame takes a form involving minimum energy; if the pressure is the same on both sides the total curvature is everywhere zero, and the edges comply with enforced boundary conditions. In the same way the strata in the smectic state must also, while obeying boundary conditions, arrange themselves so that the potential energy is a minimum.

Simplicity and symmetry imply less storage of energy than unnecessary complication and lack of symmetry. Let us consider possible methods of arrangement in declining order of symmetry.

If strata, originally plane and parallel to each other, are forced out of this arrangement, which is the simplest of all, they must tend to take the cylindrical form which comes next in simplicity. If the disturbing influences are complicated, the various attempts to adopt the cylindrical form must in some way be accommodated to each other. A set of strata of even thickness, bent into cylindrical form, is so grouped round the axis of the cylinder that the normals to the strata at all points intersect the axis at right angles. It is not possible, however, to divide a mass of the smectic substance into cylindrical groupings of this kind; the various groupings cannot be made conformable with each other.

In the next order of simplicity the normals to the strata still meet in a line, but are inclined to it, forming cones of revolution, the vertices of which are points on the line, the inclination being constant in all directions radiating from any point on the line. This is illustrated in various preceding figures, for example Fig. 4. Each cone is symmetrical about its axis.

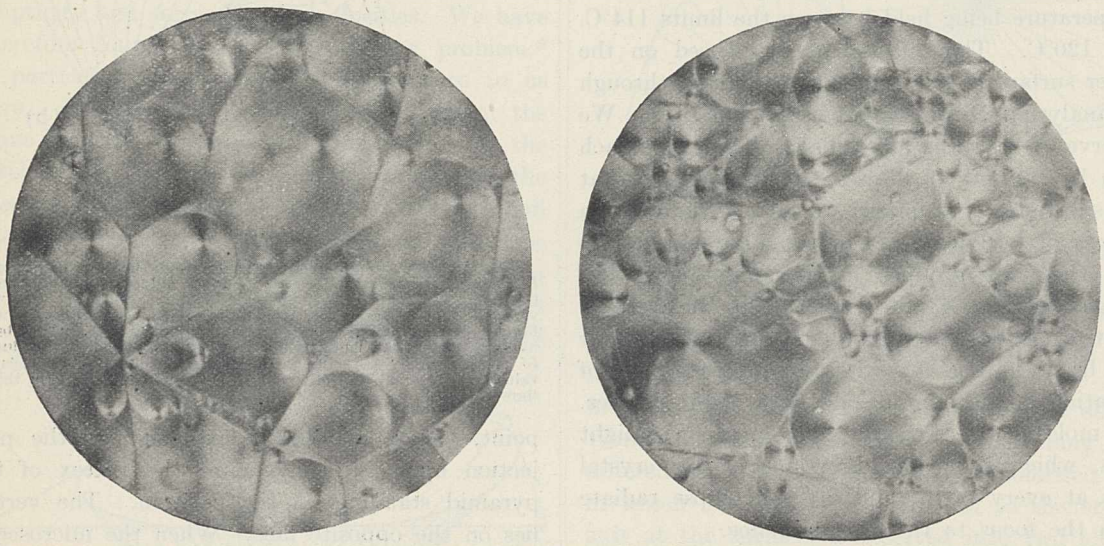


FIG. 12.—Two photographs of the same portion of a smectic preparation, but in that on the right the upper surface is in focus, and in that on the left the lower. In the lower left hand portion of the photograph on the right is a fairly regular six-sided polygon, of which the centre is occupied by an ellipse which is nearly a circle. A number of smaller ellipses lie within the same polygon. The axes of all these ellipses are directed to a point. When the other surface is brought into focus this point is seen to be the meeting place of six polygon edges, as is shown by the illustration on the left. This point is the vertex of a pyramid standing on the six-sided polygon. The six lines that meet in a point on one face are the upper edges of wedges of which the lower edges are the sides of the polygon on the other face. They are separately at right angles to these lines because focal conics, however viewed, always seem to intersect at right angles. See Fig. 10.

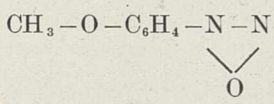
It is this arrangement which is adopted. Every normal to the strata is anchored on two lines which are focal conics. Every boundary surface of the strata is as symmetrical as possible, being at right angles to series of cones of revolution; and the various sets of surfaces are conformable to each other as we have seen. The cyclides are the only surfaces which fulfil these conditions. The geometry of the cyclide was considered by Clerk Maxwell[6], who pointed out that if the rays in a beam of light pass through two focal lines, the lines are necessarily parts of focal conics. The

wave surfaces are equally spaced cyclides to which all the rays are normal.

A useful list of substances which may exist in the smectic state is given by Friedel in the paper already referred to[2]. The azoxybenzoate is often taken as typical, as it is easily made to show all the smectic characteristics.

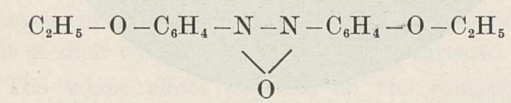
Nematic Crystals

The second of the three classes of liquid crystals outlined by Friedel, was called by him 'nematic', from the singular appearance of mobile threads, either free in the interior of the substance or attached more or less to the bounding plates. These have none of the focal conic structures of the smectic substances, having in fact no stratification. They possess optical properties, however, and therefore some degree of molecular arrangement. What that arrangement is may well be inferred from a recent determination of the solid crystal structure by Bernal and Crowfoot[7]. *Para*-azoxyanisole and *para*-azoxyphenetole are typical nematic substances.



Para-azoxyanisole

Solid $-116°-$nematic $-133°-$liquid



Para-azoxyphenetole

Solid $-135°-$nematic $-165°-$liquid.

X-ray analysis shows that the molecules in the solid lie parallel to one another, but cannot be clearly separated into layers. They interleave one another, or, to use the description by the authors referred to, they are imbricated. Certain indications found on the X-ray photographs show also that the degree of interpenetration is not sharply defined but is variable about an average value. Since the change from solid to the 'liquid crystal' form is so easy, there cannot be much variation in arrangement or bindings, and the natural inference is that, even more in the latter than in the former phase, the interpenetration lengthways is variable and easily effected. We should therefore conceive of the substance as owing its mobility to the facility with which the molecules can be drawn past each other, while retaining a strong tendency to acquire or retain a parallelism between the long dimensions of the molecules and the direction of drawing.

Another striking characteristic of the nematic state is the tendency for the molecules to be attached sideways to the slide or the coverslip. If once a solid crystal has formed between the two glass surfaces, it is difficult to remove all traces of its having done so. The substance may be completely melted and allowed to return to the nematic state, whereupon it will recrystallise more or less according to the same plan as before. The melting does not remove all the molecules adhering sideways to the glass, and enough remain to redirect the molecules in their former orientation in each separate part of the preparation. In the microscope, when the Nicols are crossed, the appearance is that of a map in which the different countries are differently tinted, because the general direction of the molecules in each part is peculiar to that part. In each part the direction may be the same right through the preparation from one glass surface to the other, especially if the layer is thin. If one or both of the Nicols are rotated, the alternations of light and dark are the same as if the preparation were a section of a uniaxial real crystal. Yet the substance is liquid (Friedel, *loc. cit*). If particles of dust or other intrusions wander through it they move freely, while the optical effects are unchanged. The orientations of the molecules are governed by those on the surface, and even if there is a stream flowing, they do not diverge from the common orientation of the section in which they are. But, if they move into another section, they change the old orientation for a new one.

Suppose now that the cover slip is moved, either by translation or by rotation with respect to the slide. In many places it must consequently happen that the orientation of the molecules on the top face is different from the corresponding orientation on the face below. The angle between them is α, let us say. It then appears that there is a gradual transition from one orientation to the other on the way through ; the substance assumes a helicoidal or twisted arrangement. If a polariser is set parallel to the molecules on the lower surface, the analyser, in order to obtain extinction, must be set, not in the perpendicular direction but at an angle α thereto. We have a straightforward example of the twisted medium which we have already considered. Both ordinary and extraordinary rays follow the screw-like arrangement of

the structure, the vibration in the one remaining always normal to the molecule, and therefore to the optic axis, while the other vibration is always parallel to it. In this case there is no deflection of the extraordinary ray.

The substance in the nematic state does not always assume the simple arrangement in plane sheets, in which the axes are parallel to the surface. If it is cooled quickly from the amorphous phase, or if less care is taken in the preparation of the glass plates, it becomes full of complicated vortices and intertwinings. Among these are the fine lines or threads from which the phase derives its name ; they are especially obvious where the preparation is thick. The threads are lines of discontinuity giving rise to optical effects, in accordance with the calculations made above. A thread might be a line which is the meeting place of crystal axes at all points of its length, as in the smectic case. There is now no necessity, however, for the line to be part of an ellipse or hyperbola, because it has no companion with which to form a pair of focal conics. Or again, it might be a line round which the medium is circulating, corresponding to a vortex ring, which is either complete or anchored at two ends. The molecules and the optic axes are then tangential to circles having the line as axis. Sometimes a line marks the boundary between two portions in which the axial directions are different.

In these cases, the ordinary ray is not deflected as it passes by the thread, unless it passes very close to it. There must then be a deflection of the ordinary ray because the thread is visible. It may be that there is actually a hollow cylinder—perhaps vacuous—providing a reflecting surface ; or it may be that the excessive strain of the medium close to the thread actually alters the refractive index of the ordinary ray.

The latter explanation would involve the introduction of a principle not used hitherto in these considerations. It has been sufficient, so far, to ascribe the optical effects to geometrical arrangement. The extraordinary ray, on the other hand, may be deflected, since it passes through a region in which the crystal axis is continuously changing its direction in the plane containing axis and ray.

FIG. 13.—The two photographs show the same substance, *para*-azoxyphenetole in the nematic phase, at two moments separated by as short an interval as possible. The only difference is that the position of the analyser in one case is approximately at right angles to its position in the other. No polariser. The clearer portion of each photograph is seen by ordinary rays ; and the other by extraordinary rays.

From this point of view we see at once the explanation of a very remarkable and characteristic appearance of the nematic substances, which is illustrated in the photographs of Fig. 13. These are photographs of the same preparation, taken one after the other as quickly as possible so as to avoid changes due to the continuous movement of the liquid. The light entering from below is not polarised but passes through an analyser after crossing the preparation. The obvious difference between the two photographs is due to the fact that the analyser was rotated through about 90° between the two exposures. The threads that look narrow and clear in one photograph are distorted in the other ; a close comparison will show that otherwise the two photographs are identical.

The remarkable feature which demands explanation is the fact that all the threads in one part of the picture should be clear simultaneously, while in another part they are all blurred. We remember, however, that there can be a skin or pellicle, to use Friedel's term, in contact with the glass surface; in other words, the previous existence of a solid crystal there has left molecules on the glass which all point the same way, like a flock of birds on the ground which all head up into the wind. This sets the orientation of other molecules in the near neighbourhood of the glass, and though the molecules may be orientated in all kinds of ways between the top and the bottom of the preparation, the change is never discontinuous except in the 'thread' itself; even then the continuity passes round the thread, if not through it. Consequently the ordinary rays emerge with their vibrations perpendicular to the axis of the pellicle at the point of emergence; though when the rays passed by the thread, the vibrations were all parallel or perpendicular to the thread, according to the view which we take of the nature of the thread. The vibrations of the extraordinary rays are all perpendicular to those of the ordinary. The analysing Nicol can therefore be set so as to extinguish all the extraordinary rays and transmit only the ordinary, so that the threads are seen clearly. If the Nicol is set so that the view is obtained by means of the extraordinary rays, the images are blurred because those rays are deflected out of their course by going near the threads.

The whole effect depends on the compelling power of the pellicle, setting an arrangement at the surface to which the internal arrangement, whatever it may be at a distance from the surface, must gradually conform as the distance from the surface diminishes. The vibrations have been orientated in a different direction at each point of the tortuous thread, but have all been pulled into one direction when they emerge. In Fig. 13 there are two regions; in one of them the molecular direction in the surface happens to be more or less at right angles to the direction in the other: so that when one part, seen by ordinary rays, is clear, the other, seen by extraordinary rays, is confused. The optical effects of nematic threads have been studied by H. Zocher and his colleagues[8].

When the *para*-azoxyanisole is cooling down from the liquid, the first appearance of a change of phase is the formation of separate groups of molecules, which between crossed Nicols give the effect illustrated in Fig. 14. Each group shows, besides finer details, a cross, the arms of which are parallel to the principal planes of the Nicols. A similar effect may be observed in certain solids, such as strontium carbonate or salicin, and occasionally lavas and glasses, and in organic substances such as cholesteryl acetate. It is an indication that in each group there is a nuclear point from which the axes of minute crystals radiate uniformly in all directions. In two of those directions, mutually at right angles, the

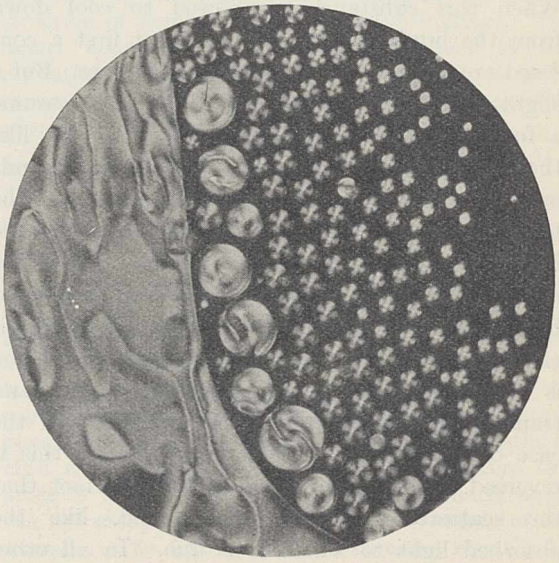


FIG. 14.—*Para*-azoxyanisole cooling, between crossed Nicols. On the left the nematic state is advancing. Small drops are forming in the liquid on the right. The arms of the crosses are parallel to the principal planes of the Nicols. The larger drops are formed by coalescence of the smaller.

axes of the crystals are parallel respectively to the principal planes of the crossed Nicols. If the preparation is rotated with respect to the Nicols, the cross does not move. The group is therefore independent of any pellicles; it is floating freely in the middle of isotropic liquid. The molecules either radiate from the nucleus in the centre, or are arranged along concentric circles as if there were a vortex. Either arrangement gives the cross. On one side of Fig. 14, the groups are coalescing and are attaching themselves to the glass above and below. The connexions are irregular but there are traces of the original simple arrangements of the groups. On the border between the liquid crystal phase are larger groups formed by the coalescence of smaller groups.

Cholesteric Crystals

The third class of liquid crystals has been termed by Friedel the cholesteric. In some ways

its properties resemble those of the smectic and nematic classes. But we meet here with a new effect, a brilliant coloration of which the causes and laws have never been fully explained.

We may take as an example

$$C_6H_5-CH=CH-CO-O-C_{26}H_{43}$$

Cholesteryl cinnamate.

Solid $-156°$ – cholesteric $-197°$ – liquid.

When this substance is allowed to cool down from the liquid phase, it presents at first a confused appearance of a focal conic structure. But a slight mechanical disturbance causes it to assume a form in which it reflects brilliant colours like those of a peacock's feather. The colour depends on the temperature, being vivid green at the higher temperatures and golden-bronze at the lower. But the most remarkable effect is that the reflected or, more correctly speaking, scattered light, is circularly polarised. If the incident light is circularly polarised, it is reflected if the circulation is represented by a right-handed screw, and transmitted if the screw is left-handed. In the case of some other cholesteric substances this is reversed. More remarkable still is the fact that the scattered light is right-handed, like the absorbed light to which it is due. In all other known cases of the reflection of circularly polarised light the sense of the rotation is reversed.

These substances, when in their characteristic state, are optically active to an extraordinary degree, represented sometimes by as much as a whole turn in the hundredth of a millimetre.

This short account of the chief properties of 'liquid crystals' is very far from complete. Nothing has been said of the influence of electrical and magnetic fields on molecular arrangement, which is strong in the case of substances in the nematic phase but absent in the smectic, except during the process of cooling from the liquid. Nor has reference been made to the peculiar facility with which the molecules of liquid crystals dispose themselves in particular directions on fresh cleavage faces of solid crystals. Nor have the viscosity effects been described. In spite of these omissions, the account may help as an introduction to the extensive literature of the subject, the more so because the accumulated observations are scattered over many scientific journals, and because also the various workers are far from agreement as to their interpretations.

[1] O. Lehmann, "Über fliessende Kristalle", *Z. phys. Chem.*, **4**, 1889.
[2] *Ann. Phys.*, 9, **18**, 273 ; 1922.
[3] *Trans. Faraday Soc.*, **29**, 881 ; 1933.
[4] *Comptes rendus*, **180**, 265 ; 1925.
[5] *Bull. Soc. Min.*, **42**, 42 ; 1919. See also *Proc. Roy. Inst.*, **28**, 89; 1934.
[6] Collected Researches, **2**, 144.
[7] *Trans. Faraday Soc.*, **29**, 1032 ; 1933.
[8] Zocher and Birstein, *Z. phys. Chemie*, A, **142**, 113.

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Progress in Wool Research

A PAMPHLET recently issued by the Wool Industries Research Association summarises, under the title "Scientific Research applied to the Wool Industries", a number of the practical results of the work. These include the invention of durable sheep-marking fluids completely removable in subsequent processing and leaving no traces in the finished fabric. The investigations on the recovery of wool grease from scouring liquors have contributed largely to the development of three processes in use at Bradford and elsewhere, while those on wool scouring, for example, have made possible the actual detection and commercial control of variable alkalinity by means of indicator cloth. The discovery of the chemical changes responsible for discoloration in carbonising have enabled adequate precautions for prevention to be taken. Improved 'ionised' oils have been developed for the lubrication of wool. Fundamental issues underlying the woollen spinning process have been elucidated, a new principle in roller drafting has been discovered for use in the spinning of dry combed rovings and a general relation developed between count, twist and strength for single worsted yarns. Causes of deterioration of spinning ability of dyed wool have been ascertained and of damage in fabrics through lead staining in weaving. Mothproofing and preservation against moulds and mildew have been important fields of work, and in these and in many other ways the application of quantitative measures has assisted in the control and efficiency of the numerous processes with which the wool industry is concerned.

Association of Scientific Workers

THE annual report of the Executive Committee of the Association of Scientific Workers presented to the Council on February 24 refers to the formation of a National Parliamentary Science Committee as an outcome of negotiations with the British Science Guild as the outstanding special work of the year. The support of twelve leading institutions has been obtained, and the committee includes Sir James Henderson, Prof. Miles Walker, Prof. Blackman, with Commander Bernacchi as chairman, and Mr. A. Howard and Mr. H. J. W. Stone as joint honorary secretaries. In consequence, the Parliamentary Committee of the British Science Guild and of the Association have been disbanded. The compilation of a "Handbook of Extra-University Research in Pure and Applied Science", giving data concerning commercial, endowed and private research laboratories, has been completed and negotiations for publication are in progress. It is believed that the handbook will serve as an advertisement of British research activities and of the interest taken by British industrialists in maintaining the highest efficiency in factories. The book may become a standard work of reference alongside the "Universities Yearbook" and the "Year-Book of Scientific and Learned Societies".

THE Association has been active in combating the evil of bogus degrees and has been in negotiation with the universities to secure their support of successive Bills introduced in the House of Lords by Lord Jessel to deal with this evil. The Association collected a considerable amount of information regarding the granting of degrees by five different British 'degree-mongers' but has so far been unable to induce the universities to withdraw their opposition at the third reading of the Bills. The finance of the research associations has received attention and is being considered by a joint Committee of the Association and the British Science Guild. The production of "Science in Parliament" has continued and a memorandum has also been prepared on the relation of the unification of national transport, the construction of ship-canals across Britain, the reconstruction of derelict canals and land-drainage. The report concludes by directing attention to the resolution passed that members should seek to assist towards a better adjustment between scientific advances and social progress.

Absence of Winter Rains in England and Wales

THE Director of the Meteorological Office, Air Ministry, states that the rainfall over England and Wales has been less than the average for nine out of the last eleven months. August, November, December and February stand out conspicuously for their dryness. In October and January the fall was slightly above the average but there is not a single month of large excess. Taking the period as a whole, the rainfall was everywhere less than the average except along a strip of the east coast from Newcastle to Hull and again near Yarmouth. There were two areas in which the deficiency was particularly large, the fall amounting only to about two thirds of the average. The first of these is bounded roughly by the counties Breconshire, Bedfordshire, Somersetshire and Surrey; the second includes the Cheshire plain and the coastal strip of Lancashire. The absence of the winter rains on which we rely to such a large extent for keeping up our water supplies is remarkable. The rainfall for the four months November–February was less than half the average over a great part of the country south of a line from Aberystwyth to Yarmouth, and there are regions of similar deficiency to the west of the Pennines and in south Lancashire. In January, heavy falls amounting to about 20 inches fell in Snowdonia and the English Lake District, but less than two inches were measured over the eastern half of England, and less than an inch in the neighbourhood of Middlesbrough and the Wash. The deficiency for February was also marked. Totals of more than an inch were confined to Snowdonia, the neighbourhood of Borrowdale and parts of the north-east coast. Locally, for example at Patching Farm near Littlehampton, there was no measurable rainfall for the whole of the month, a very unusual occurrence. The partial failure of the winter rain has been the most severe since the memorable winter of 1879–80, which, however, followed a wet summer, whereas the summer of 1933 was dry.

Award to Dr. F. W. Pennell

THE first award of the George W. Carpenter fund for encouragement of scientific research was made on

February 20 by the Academy of Natural Sciences of Philadelphia to Dr. Francis W. Pennell, curator of botany in the Academy, for his work and study on the snapdragon family (Scrophulariaceæ) of eastern North America. In presenting the 250 dollars honorarium at the annual meeting, the president announced that this fund also will permit publication of Dr. Pennell's book on the subject. The George W. Carpenter fund is a bequest from the late Mrs. Ellen D. C. Bennett, in memory of her father, one of the Academy's earliest members, who served as treasurer from 1826 until his death in 1860. Dr. Pennell was appointed curator of botany at the Academy in 1921, and under his direction this Department has become one of the largest of its kind in the United States, containing at the present time more than 600,000 specimens of plants and flowers from all parts of the world. Among these are some of the oldest and most valuable of American collections.

Ray Society

At the annual general meeting of the Ray Society held on March 13, the following officers were re-elected : *President*, Sir Sidney Harmer ; *Treasurer*, Sir David Prain ; *Secretary*, Dr. W. T. Calman. Mr. J. M. Offord was elected a vice-president in succession to the late Canon G. R. Bullock-Webster, and Mr. R. S. W. Sears, Mr. M. A. C. Hinton and Mr. A. G. Lowndes were elected new members of Council. The Council's report directed attention to the decline in the receipts from all the regular sources of the Society's income, and stated that unless further support for the Society is obtained, a regrettable curtailment of publications may soon become necessary. It was stated that the plates for the second volume of Prof. T. A. Stephenson's "British Sea Anemones" are being engraved, and it is hoped that the volume will soon be in the press. The Council reported with gratitude the receipt of a donation of £30 towards the cost of this volume from Miss Teresa Gosse, the grand-daughter of Philip Henry Gosse, author of the "Actinologia Britannica" (1860).

Soviet Stamps in Commemoration of Mendeléeff

THE Soviet postal authorities have issued a series of new postage stamps to commemorate the centenary this year of the birth of Mendeléeff. The new issues are of five, ten, fifteen and twenty kopek denominations. The five and the twenty kopek denominations bear a design of the Mendeléeff monument against a background of his table of the periodic system of elements ; the ten and fifteen kopek denominations bear a portrait of Mendeléeff, also against a background of the table of the periodic system of elements. All the stamps bear the commemoration date 1834–1934.

Vital Statistics for the Year 1933

THE Registrar-General has issued a provisional statement of the figures for birth-rate, death-rate and infant mortality in Great Britain during the year 1933. For England and Wales, the live births and the deaths were respectively 14·4 and 12·3 per 1,000 resident population, and the deaths of infants less than 1 year old, 64 per 1,000 registered live births. For the fifth year in succession the birth rate was the lowest on record, being 0·9 per thousand below that of 1932, and 1·4 below that of 1931. The death rate was 0·3 above that for 1932 and is the same as that for 1931. The infant mortality rate was 1 per 1,000 below that for 1932, and with the exception of the year 1930 (60) is the lowest on record.

Announcements

AT the annual general meeting of the Physical Society, held on March 16, the following officers were elected : *President*, The Right Hon. Lord Rayleigh ; *Vice-President*, Dr. D. Owen ; *Secretaries*, Dr. Allan Ferguson (Papers), Dr. Ezer Griffiths (Business) ; *Foreign Secretary*, Prof. O. W. Richardson ; *Treasurer*, Mr. R. S. Whipple ; *Librarian*, Dr. J. H. Brinkworth ; *New Members of Council*, Mr. H. H. Emsley ; Prof. H. R. Robinson.

THE Institute of Physics has put forward a scheme for the training and certificating of laboratory and technical assistants in physics, and proposes in due course to set up an appointments register. Candidates for the Institute's certificates must attend approved courses of instruction and pass examinations in accordance with the regulations issued. It is understood that evening class courses for the Institute's certificates will be commenced in September next in London.

APPLICATIONS are invited for the following appointments, on or before the dates mentioned :—Engineers at the Fuel Research Station, East Greenwich—Establishment Officer, Department of Scientific and Industrial Research, 16 Old Queen Street, S.W.1 (March 26) An assistant in the Admiralty Technical Pool for duty at the Admiralty Compass Department—Secretary of the Admiralty (C. E. Branch), London, S.W.1 (March 28). A veterinary officer under the Devon County Council—County Medical Officer, 4 Barnfield Crescent, Exeter (March 29). Two junior assistant engineers on the Manchester Corporation—City Engineer (March 30). Engineer and manager of the Weymouth Waterworks Company—Chairman (April 3). Water engineer and manager and gas examiner to the County Borough of Swansea—Town Clerk, Guildhall, Swansea (April 7). Principal of the County Technical College and School of Art, Newark—Clerk to the Governors (April 10). A demonstrator in zoology at University College, Nottingham—Registrar (April 11). A demonstrator in the Department of Inorganic and Physical Chemistry at Bedford College for Women, Regent's Park, N.W.1—The Secretary (April 21). Two technical assistants (A. 587/8) and a draughtsman (A. 589) at the Royal Aircraft Establishment, Farnborough, Hants—Chief Superintendent, quoting reference number above. Two resident staff tutors for adult education, University of Birmingham—Director of Extra-Mural Studies (April 23). University professor of anatomy at St. Thomas's Hospital Medical School, London—Academic Registrar, University of London, S.W.7 (May 16).

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.*]

Supraconductivity of Films of Tin

EXPERIMENTS on the relation of high frequency currents to the phenomenon of superconductivity led to work at Toronto with films of superconducting metals. The films (of tin) were produced by 'tinning' the surface of fine wires which themselves were not superconducting: in the early experiments a coating of tin 2×10^{-4} cm. in thickness was 'wiped' on constantan wire of 0·016 cm. diameter. In this way one obtains the equivalent of a thin cylinder of superconducting metal, and the resistance of the whole becomes zero below the transition temperature of the superconducting element used[1].

With the intention of studying further the effect of high frequency currents, samples of such coated wires were plated with other metals—for example, copper and nickel—which are not superconductors; an example of such a combination is constantan covered with tin and then plated with copper. The diameters of the wires forming the core were as follows: for constantan 0·056 cm., for copper 0·040 cm. and for nickel 0·045 cm.

Preliminary experiments were carried out on these samples to confirm their reaction with respect to direct currents—the ordinary superconductivity test—and it was found that thin films of tin cease to show superconductivity when these films are themselves plated over with a film of a non-superconducting metal, for example, copper or nickel. This surprising result shows itself only with thin films, but a number of repetitions of the experiments renders the results unmistakable. The accompanying table shows the nature of the phenomenon: so far, only the superconductor tin has been tested in this way.

No.	Sample	Thickness of Tin Film (cm. × 10^{-5})	Thickness of outer layer (cm. × 10^{-5})	Superconductive Action, direct current of 200 ma.
1a	Constantan-Tin	10	0	Transition point 3·69°K
1b	Constantan-Tin-Copper	10	100	Not superconducting at 2°K
2a	Copper-Tin	9	0	Transition point 3·58°K
2b	Copper-Tin-Copper	9	100	Not superconducting at 2°K
3a	Nickel-Tin	9	0	Transition point 3·42°K
3b	Nickel-Tin-Copper	9	100	Not superconducting at 2°K
4	Constantan-Tin	6·8	0	Transition point 3·49°K
5	Constantan-Tin	2	0	Transition point 2·48°K
6	Constantan-Tin-Copper	18	40	Not superconducting at 2°K
7	Constantan-Tin-Copper	4	20	Not superconducting at 2°K
8	Constantan-Tin-Nickel	15	30	Not superconducting at 2°K
9	Constantan-Tin (wiped)	90	0	Transition point 3·68°K
9a	Constantan-Tin-Copper	90	80	Transition point 3·44°K
10	Constantan-Tin (electro-plated)	200	0	Transition point 3·76°K
10a	Constantan-Tin-Copper	200	80	Transition point 3·73°K
11	Tin Wire	diameter	0·085	Transition point 3·77°K

It is seen that as the film of tin increases in thickness, a point is reached at which the superconducting property of the tin film is not lost by surface plating. This phenomenon will undoubtedly be of importance in framing a satisfactory theory of superconductivity—a consideration of utmost importance in dealing with metallic conduction. This work is being carried on by J. O. Wilhelm and A. D. Misener.

E. F. BURTON.

McLennan Laboratory,
University of Toronto.
Feb. 17.

[1] E. F. Burton, "Superconductivity" (University of Toronto Press, and Oxford University Press), p. 70. J. C. McLennan, NATURE, **130**, 879, Dec. 10, 1932.

Persistent Currents in Supraconductors

UNTIL recently it was generally assumed that it was possible to predict, by the ordinary electromagnetic equations, the persistent current produced in a supraconductor cooled below the transition point in a constant external magnetic field after the field was switched off. Thus H. A. Lorentz[1] calculated the current induced in a supraconducting sphere, that is, the effective magnetic dipole when an external magnetic field is established.

According to results recently published by Meissner and Ochsenfeld[2], the matter is not so simple as might at first sight appear. Instead of the lines of force being 'frozen in' as had been previously assumed would happen when a supraconductor was cooled below the transition point in a magnetic field, it appeared that the field increased in the neighbourhood of the supraconductor, which behaved as a body of zero permeability. If this were so, the flux of induction in the supraconductor should be zero and one might expect, in contradistinction to the old view, that no persistent current or effective induced dipole would be produced by switching off the external field.

The following experiments seem to show that although supraconductors do not conform to the older theory, neither do they behave as though they had zero permeability.

(1) A solid tin sphere of 1·5 cm. radius was cooled from 4·2° K. to 2·5° K. (the liquid helium was produced in a liquefaction apparatus utilising the expansion method of Simon) in a field of 70 gauss. When the field was switched off, the magnetic moment of the sphere was observed with a test coil. Its magnitude was about one sixth of that calculated according to the Lorentz equation.

The magnetic moment remained almost constant whilst the temperature of the sphere rose from 2·5° to 2·9°; with a further rise in temperature it decreased steadily, becoming zero at 3·7°, the normal transition point of tin. Plotting the magnetic moment against the temperature, one obtains a curve of similar shape to that found for the magnetic threshold values.

(2) The same sphere was cooled to 2·5° without any external magnetic field, a field of 230 gauss (higher than the threshold value at this temperature) was switched on and immediately switched off. The magnetic moment thus produced in the sphere at 2·5° was 8 per cent greater than that produced in the previous experiment using 70 gauss, but as the temperature rose it decreased and at 2·9° it reached the same value as the magnetic moment at this temperature in the previous experiment. From 2·9° to 4° the curve coincided with that found in experiment (1).

(3) Similar experiments to those described above

were carried out with a hollow tin sphere of the same radius, the spherical space in the middle being equal in volume to one half the volume of the sphere. The magnetic moments produced in the hollow sphere were two to three times greater than those obtained with the solid sphere.

In all these experiments the magnetic field was produced by a cylindrical coil in the middle of which the sphere was placed, all iron being excluded. Although the field near the sphere was thus fairly homogeneous, we think it possible that the observed phenomena may be influenced by slight inhomogeneities of the external field. In a completely homogeneous field it would seem possible that the method of cooling might affect the results. In order to test this, we cooled the spheres from the poles and also from the equator. This did not seem to make any difference, the magnetic moment observed being of the same order of magnitude in either case.

As a result of these experiments, it seems certain that the effective permeability of substances when they become supraconducting decreases, as observed by Meissner and Ochsenfeld. On the other hand, it appears clear that under our experimental conditions the permeability does not vanish entirely, as might be expected in view of the almost infinite conductivity, or if it does vanish, it only does so in certain regions and not throughout the whole volume of the supraconductor.

In conclusion, we would like to express our thanks to Mr. T. C. Keeley for his advice and assistance in various phases of the work.

K. MENDELSSOHN.
J. D. BABBITT.

Clarendon Laboratory,
Oxford.
Feb. 17.

[1] Comm. Leiden, Suppl., Nr. 50 *b*, 1924.
[2] *Naturwiss*, **21**, 787; 1933.

Some Thermal Properties of Condensed Helium

IN the following communication we give the results of some preliminary measurements with condensed helium:

1. The heat of fusion is 6·75 cal./gm.-atom at 4·0° and 5·1 cal. at 3·4°.

2. The density of solid helium in equilibrium with the liquid phase is 0·23 at 4·0° and 0·22 at 3·6°.

3. The density and compressibility of liquid helium have been measured at 2·4° and 4·5°. They are in good agreement with the data recently published by Keesom[1]. We would add only that the compressibility still falls appreciably with higher pressure.

4. The compressibility of solid helium could be measured roughly, the result being about $1{\cdot}5 \times 10^{-3}$ reciprocal atm. at 3·7° and 115 atm.

5. The specific heat of solid helium was determined between 2·7° and 3·7° at a density of 0·23. C_v agrees well in this region with a Debye function for $\Theta = 32{\cdot}5°$. This small value (the smallest hitherto observed), which we find in spite of the small atomic weight, is another consequence of the very weak interatomic forces. From $\Theta = 32{\cdot}5°$ follows a zero point energy of 73 cal./gm.-atom, compared with a thermal energy of only 1 cal. at 4°. We may mention that this value agrees well with the deviation from Trouton's rule if we attribute this to the zero point energy[2].

6. Measurements of adiabatic expansion were carried out in connexion with a proposed procedure[3] for lowering temperatures by changing the volume of condensed helium. The coefficient $\gamma = -(\delta \ln T/\delta \ln v)_s$ was measured for the liquid phase as a function of temperature and pressure. We may mention as an example, that starting at 4·6° and 130 atm., 2·4° is reached by expanding to the vapour pressure. Expansion experiments with solid helium have not yet been carried out, nor accurate experiments on the more easily made adiabatic expansion starting from the solid at equilibrium pressure. We have done only one preliminary experiment starting from partly solidified helium at 4°, and this showed an appreciable increase in the cooling effect as compared with the effect obtained with only liquid present. (The data given above, however, enable us to calculate these cooling effects. Starting with solidified helium at the equilibrium pressure at 4°, one should reach a temperature of 1·4° by expanding to the vapour pressure. As according to the measurements of Keesom[4] on the thermal expansion an adiabatic expansion of the liquid below the λ-point should lead to a temperature rise, a lower temperature will be obtained by expanding only until the substance is just melted. Keesom's entropy diagram of the liquid[5] shows that in this case a temperature 0·15° lower should be reached. Definite predictions of the cooling effects when starting at lower temperatures cannot be given yet.)

7. The knowledge of the specific heat of the solid phase enables us to fix the zero point of entropy according to Nernst's Theorem. The absolute value of the entropy of the liquid can now be calculated using the values of the heat of fusion, the data of adiabatic expansion and the specific heats. Connexion can be made through the known values of vapour pressures and heats of evaporation with the theoretical value of the entropy of the gas, putting the statistical weight equal to unity according to the spectroscopic observations. We find good agreement, the resulting chemical constant being −0·62 compared with the theoretical value −0·68.

The investigations were carried out in 1932 in Breslau. Their continuation is being undertaken in the Clarendon Laboratory.

R. KAISCHEW.

Sofia.

F. SIMON.

Oxford.
Feb. 25.

[1] W. H. and A. P. Keesom, *Physica*, **1**, 128; 1933.
[2] K. Bennewitz and F. Simon, *Z. Phys.*, **16**, 197; 1923.
[3] F. Simon, *Z. Phys.*, **81**, 824, 838; 1933; see also W. Meissner, *Z. Phys.*, **81**, 832; 1933; and W. H. and A. P. Keesom, *Physica*, **1**, 161; 1934.
[4] W. H. and A. P. Keesom, *Kon. Akad. v. Wetensch. Amsterdam*, **36**, Nr. 5; 1933.
[5] W. H. and A. P. Keesom, *Physica*, **1**, 161; 1934.

A Mercury-Sealed Water-Cooled Rotating X-Ray Target

INSPIRED by the magnificent X-ray tube with spinning target designed by Müller[1] and now in operation at the Davy Faraday Laboratory of the Royal Institution, we have considered the feasibility of completely sealing off the rotating anode by means of mercury after the manner of the classical Torricelli experiment.

At first sight such a proposition seems absurd for

an X-ray tube containing a glowing filament, but we have overcome the difficulty very simply by covering the inner mercury meniscus with a layer of Apiezon high-vacuum oil. Fig. 1, which is self-explanatory, shows diagrammatically a tube which we have constructed and proved to work, not as yet, owing to lack of resources, with the large currents Müller has used, it is true, but still under sufficiently stringent conditions to demonstrate the essential soundness of the method. Even with ordinary steel steam tubes, unpolished on their inner surfaces, the vacuum was found to hold exceedingly well. The annular space containing the mercury was about

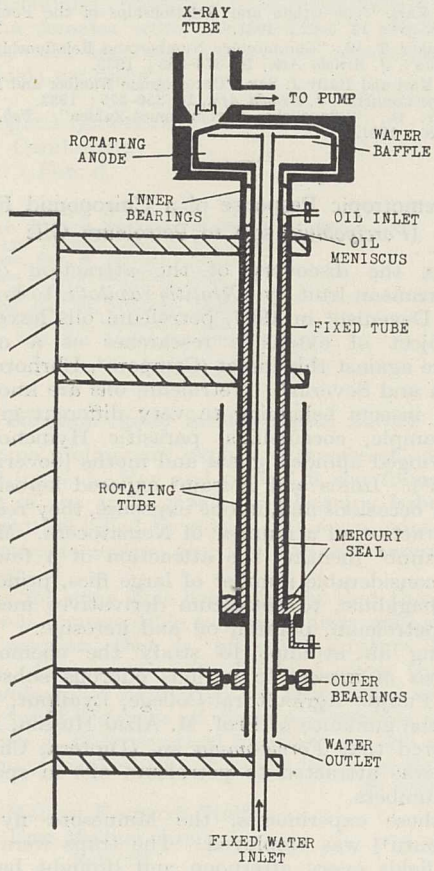

FIG. 1.

¼ in. wide, and the pump used was a two- or three-stage oil diffusion pump. Incidentally, these experiments show that mercury gauges can safely be used in combination with such oil diffusion pumps, if the precaution is taken of covering the mercury meniscus with a layer of high-vacuum oil.

The expenses of this investigation were met by grants from the Government Grant Committee of the Royal Society, and the Commissioners of the 1851 Exhibition. For the mechanical workmanship we are indebted to Mr. A. Robinson of this department.

W. T. ASTBURY.
R. D. PRESTON.

Textile Physics Laboratory,
University of Leeds.
Feb. 20.

[1] A. Müller, NATURE, 124, 128, July 27, 1929.

Radio-Geological Survey of Czechoslovakia

BOHEMIA is an excellent region for radio-geological investigation. In the first place, we have the ore region of Jáchymov (Joachimsthal), where pitch-blende is found. However, in the Krkonoše (Riesen Gebirge) and in the Jizera Mts., where there are no deposits of pitch-blende, strong radioactive springs (containing up to 200 Mache units) occur very frequently along faults, contacts, etc. This district has been investigated by us radio-geologically in the same manner as that in which Genser investigated the German portion of the Krušné Hory (Erz Gebirge)[1].

During the last three years, we have gathered together much material by various experimental methods. Chiefly, so far as was possible, the radioactivity of springs in the whole area of the Krkonoše was measured systematically. The content of radium emanation was measured at different seasons of the year, the springs and their radioactivity were then marked on maps, so that radiological maps of the terrain might be formed, as suggested by Vernadskyj. These maps will be made still more complete by the investigation of the soil-atmosphere. In highly active springs the flow of the water, found to be inversely proportional to its radioactivity, was measured and its dependence on meteorological factors determined. The springs are, therefore, regarded as superficial. Further, the amount of radium was ascertained in the water of the strongest springs (of the order of 10^{-11} gm. of radium element to 1 litre of water), and its quality by Elster-Geitel's mesothorium method. We have made also precise chemical analyses of the strongest springs.

At the same time, analyses of the rocks in the neighbourhood of the springs have been made with regard to their contents in radium elements. A simplification of Joly's method has been used, in which the rock is melted in the electric furnace, in cheap iron pans[2]. Likewise, rock sections were studied from the mineralogical point of view. Correlation between geological structure and the analyses of waters and rocks were studied. It was proved, for example, that at Žalý (Heidelberg on Benecko) waters became radioactive on contact with phyllite (radium content, $8{\cdot}3 \times 10^{-12}$ per gm.) and orthogneisses (radium content, $4\text{–}7 \times 10^{-12}$ per gm.). The total length of contacts is so great that the amount of emanation in the springs of this district (100 Mache units) can be easily explained by the absorption of emanation by the water along this quite superficial contact.

A report of the first part of these investigations in the area of the Krkonoše will be published soon. We have dealt also with a large amount of material, especially from radiological investigations of the rocks from the ore region of Jáchymov and of rocks of organic origin from Bohemia and from Slovakia. This material will be completed and gradually published. The aim of the work is a radio-geological survey of the whole of Czechoslovakia.

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Radiological Institute, Prague.
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Charles University, Prague.
Feb. 27.

[1] *Geol. Rundschau*, 182; 1932.
[2] Běhounek-Santholzer, *Gerlands Beiträge z. Geophys.*, **33**, 60; 1931.

Origin of the Angiosperms

THE cyto-genetic work of the past decade has built up an increasingly impressive body of data demonstrating the evolutionary importance of fertile, true-breeding hybrids originating through doubling of the chromosome number. A considerable number of such hybrids (variously termed amphidiploids, summation hybrids, allopolyploids) have originated under observation. Particularly interesting from the evolutionary point of view are Müntzing's 'synthetic' *Galeopsis Tetrahit*, produced from *G. pubescens* and *G. speciosa*[1], and Karpechenko's *Raphano-Brassica*, an intergeneric hybrid which, were it found in Nature, would be considered a new genus[2].

An enormous body of indirect evidence suggests that similar 'summation hybrids' have occurred frequently in the development of many of the families of the angiosperms. There is even some evidence for the reticulate origin of groups larger than the genus. For the sub-family Pomoideæ, the genetical and cytological evidence for the reticulate origin of that whole group from a cross or crosses between other members of the Rosaceæ is so strong that such a theory was put forward independently by Darlington and Moffett[3] and by Sax[4].

The following suggestion for a reticulate origin of the Magnoliales, though admittedly highly speculative, is therefore not without precedent. Whitaker's recent work[5] has shown that these peculiar odds and ends do indeed form a natural order, though the affinity of certain of the genera (as, for example, *Cercidiphyllum* and *Trochodendron*) had previously been questioned. He has suggested that the genera *Tetracentron*, *Drimys*, *Cercidiphyllum*, *Trochodendron*, *Magnolia* and *Liricdendron*, agreeing as they do in nodal anatomy and chromosome number, should be placed together in one group. It is noteworthy that this group includes several genera which have been repeatedly considered as possibly transitional between the gymnosperms and the angiosperms, some of them being so placed by reason of their floral anatomy and others because of the structure of their wood. Cytologically, the group is unusual by reason of its basic chromosome number of 19, which is seldom met with among the other families of the flowering plants.

May it be possible that the Magnoliales originated from wide crosses between different groups of gymnosperms ? So far as chromosome numbers are concerned, the data are certainly suggestive. On the basis of chromosome number, the Gymnospermæ can be divided into two groups[6]. To the larger group belong the Ginkgoales, Cycadales and Coniferales with base numbers of 12 and 11. To the smaller group belong the Gnetales, two genera of which have been found to possess base numbers of 7. It will be seen that the chromosome number for the Magnoliales is exactly what would obtain were a sterile cross between these two groups to double its chromosome number.

An origin for the flowering plants has usually been sought either among the Gnetales or the Cycadales. The evidence from chromosome numbers would suggest, *as one possibility*, that relatives of each might have contributed, reticulately, to the origin of the Magnoliales. For the immediate present, the cytologist can do no more than raise the question, "May the angiosperms have originated, in part at least, from crosses between some of the simpler members of the seven chromosomed and twelve chromosomed gymnosperms ?" The morphological evidence has not, I believe, been examined from this point of view. It would be interesting to know how far it supports such a hypothesis.

EDGAR ANDERSON.

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Harvard University,
Jamaica Plain,
Massachusetts.

[1] Müntzing, A., "Cyto-genetic Investigations on Synthetic *Galeopsis Tetrahit*", *Hereditas*, **16**, 105–154 ; 1932.

[2] Karpechenko, G. D., "Polyploid Hybrids of *Raphanus sativus* L. *Brassica oleracea* L.", *Z. ind. Abst. u. Vererb.*, **48** ; 1928.

[3] Darlington, C. D., and A. A. Moffett, "Primary and Secondary Chromosome Balance in Pyrus", *J. Gen.*, **22**, 129–151 ; 1930.

[4] Sax, Karl, "The Origin and Relationships of the Pomoideæ", *J. Arnold Arb.*, **12**, 3–22 ; 1931.

[5] Whitaker, T. W., "Chromosome Number and Relationship in the Magnoliales", *J. Arnold Arb.*, **14**, 376–385 ; 1933.

[6] Sax, Karl and Hally J. Sax, "Chromosome Number and Morphology in the Conifers", *J. Arnold Arb.*, **14**, 356–375 ; 1933.
Tischler, G., "Pflanzliche Chromosomen-Zahlen", *Tab. Biol.*, **6**, 109–226 ; 1931.

Chemotropic Response of a Chironomid Fly (*Forcipomyia* sp.) to Petroleum Oils

SINCE the discovery of the attraction of the Mediterranean fruit fly, *Ceratitis capitata*, to kerosine oil by Devenish[1] in 1907, petroleum oils have been the object of extensive researches as a control measure against this insect (Compere[2], Ehrhorn[3] and Severin and Severin[4]). Petroleum oils are known to attract insects belonging to very different groups ; for example, coccinellids, parasitic Hymenoptera, ants, winged aphides, gnats and moths (Severin and Severin[5]). Imms and Husain[6] exposed kerosine oil on four occasions and, in one exposure, they recorded the attraction of a number of Nematocera. Morgan and Crumb[7] mention the attraction of a few bees and a considerable number of large flies, principally Sarcophagidinæ, to petroleum derivatives including crude petroleum, paraffin oil and kerosine.

During an attempt to study the chemotropic responses of insects to various odorous substances at the Punjab Agricultural College, Lyallpur, India, under the guidance of Prof. M. Afzal Husain, it was discovered that *Forcipomyia* sp. (Diptera, Chironomidæ) was attracted to petroleum oils in specially large numbers.

In these experiments, the Minnesota fly trap (Washburn[8]) was employed. The traps were hung up in fields every afternoon and brought back to the laboratory next morning, where they were fumigated with hydrocyanic acid gas and the entrapped flies counted. A trap containing crude petroleum oil captured a mean weekly total of 402 examples of *Forcipomyia* from October 24 to December 31, 1924 ; the maximum being 1078 flies in one week, and 275 flies in a single night on November 2, 1924. During winter, the number of flies decreased rapidly and from January to March 1925, a mean weekly capture of only 9 flies was obtained. The following different grades of petroleum oils available in the market were also tried : petrol ; kerosine oil ; crude oil used for combustion in crude oil engines ; residual oil left after the preparation of coal gas.

It was noticed that petrol which contains hydrocarbons with low boiling points was the least attractive. With the view of confirming this observation a sample of kerosine oil was distilled, and fractions distilling below 80° C., at 80°–158°, 158°–184°, 184°–220°, 220°–250° and above 250° C. were separately

collected and exposed as usual. It was discovered that fractions distilling between 158° and 184° C. attracted the largest number of flies, while those distilling below 158° C. proved to be least attractive.

In almost all cases of chemotropic responses of insects, males have been attracted in much larger numbers than the females, which reduces the value of these methods as a control measure. [Compare *Dacus zonatus* to citronella oil, 3 females to 1,000 males (Howlett[9]); *Ceratitis capitata* to kerosine oil, 3 females to 1,000 males (Severin and Severin[4]); *Swammerdamella* sp. to cinnamic alcohol, one female to 40 males (Morgan and Crumb[7]).] In the case of this chironomid, however, it is interesting to note that the females were attracted in a very great majority and constituted 91·2 per cent of all the individuals captured.

TASKHIR AHMAD.

Zoological Laboratory,
Cambridge.
Feb. 6.

[1] *Sydney Morning Herald*, 645; 1907.
[2] *J. Agr. Western Australia*, **15**, 244–245; 1907.
[3] *Bd. Agr. Forestry Circ.*, **3**, 1–7; 1912.
[4] *J. Econ. Ent.*, **6**, 347–351; 1913.
[5] *J. Econ. Ent.*, **8**, 329–338; 1915.
[6] *Ann. Ap. Biol.*, **6**, 269–290; 1920.
[7] *J. Econ. Ent.*, **21**, 913–920; 1928.
[8] *J. Econ. Ent.*, **5**, 400–402; 1912.
[9] *Trans. Ent. Soc. Lond.*, 412–418; 1912.

Nicotine Spray for the Apple Sawfly

IN some preliminary experiments carried out here in 1933 by G. L. Hey and myself, it was found that the egg of the apple sawfly, *Hoplocampa testudinea*, Klug., can be killed by means of a spray containing 0·05 per cent nicotine and 0·5 per cent commercial soft soap.

It has for some time been thought that the egg of this insect is susceptible to such a spray only shortly before eclosion, that is, after the rupture of the chorion. Our experiments, however, show that the egg is vulnerable right from the time it is laid.

The detailed results of these experiments, and a discussion of their practical implications, will appear in the next issue of this Station's "Annual Report".

W. STEER.

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Feb. 23.

Mechanism of Detonation in Lead Azide Crystals

GARNER and Gomm[1] and also Muraour[2] have distinguished between the energies of activation (critical increments) which characterise (*a*) the thermal decomposition and (*b*) the detonation of an explosive. In the case of lead azide, the value[1] for the detonation, 150,000 cal./mol. (one extreme measurement, 9·7 sec., is omitted advisedly and with Prof. Garner's concurrence), is about *three* times that for the thermal decomposition, 47,000 cal./mol.

The crystalline structure has also been examined. As determined by Miles[3], the unit cell contains twelve molecules of PbN_6. In this department, however, the radiological directorate[4] has examined lead azide in more detail; the *c*-axis of Miles is doubled, giving the cell twenty-four molecules, and the space group is found to be Q_h^{13}. It follows from this that these twenty-four molecules are arranged in eight groups each containing *three* molecules of PbN_6.

The recurrence of the value three is evidence that the criterion for detonation is closely related to the crystalline structure, and would indicate that the thermal decomposition is caused by the activation of a single molecule of PbN_6, whereas the detonation requires the simultaneous activation of all three constituents of one of the complex groupings $(PbN_6)_3$.

T. CARLTON SUTTON.

Explosives Directorate,
Research Department,
Woolwich.

[1] Garner and Gomm, *J. Chem. Soc.*, 2123; 1931.
[2] Muraour, *Chem. et Ind.*, **30**, 39; 1933.
[3] Miles, *J. Chem. Soc.*, 2532; 1931.
[4] Unpublished.

Vapour Pressure of Potassium Amalgams

IF a solution of a substance has a smaller surface tension than the pure solvent, the solute is adsorbed or concentrated at the surface, in accordance with Gibbs's theorem. It is therefore to be expected that the vapour pressure of the solvent of such a solution will be higher, when the concentration of the solute is made the same in the surface as in the interior, by continually renewing the surface, than when it is not.

The following facts, found by measuring the vapour pressure of mercury over potassium amalgams, by determining the absorption of the resonance line 2537 A. at room temperature seem to confirm this conclusion:

Diluted potassium amalgams show a much greater lowering of the vapour pressure of the mercury than would correspond with Raoult's law (an amalgam containing 1·5 atom per cent of potassium showed 30 per cent lowering of the vapour pressure). If, by careful motion, the surface is continually renewed, the vapour pressure rises almost to the value predicted by Raoult's law. Soon after the motion is stopped, the vapour pressure returns to the former low value.

The same phenomenon is caused by impurities in mercury which is not especially cleaned.

The above results explain Pohl and Pringsheim's observations[1] on the very small dependence of the sensibility and threshold of the photo effect of potassium amalgams on the concentration.

HANS H. v. HALBAN, JR.

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Zürich.
Feb. 8.

[1] R. Pohl and P. Pringsheim, *Verh. Deutsch. Phys. Ges.*, **15**, 431 1913.

Influence of Pressure on the Spontaneous Inflammation of Hydrocarbons

MESSRS. NEUMANN AND ESTROVICH have recorded[1] some experiments on the conditions of spontaneous inflammation of the mixture $C_5H_{12} + 8\,O_2$ when heated in an iron bomb and in a bomb the inner surface of which was covered with gold. The peculiar relation which they find between pressure and ignition-temperature also appears in some unpublished work of the late H. B. Dixon.

In his experiments Dixon determined, at pressures ranging from 10 to 120 cm., the lag on ignition of a jet of pentane vapour heated to a predetermined temperature and issuing into an atmosphere at the same temperature. The shorter the lag, the less is

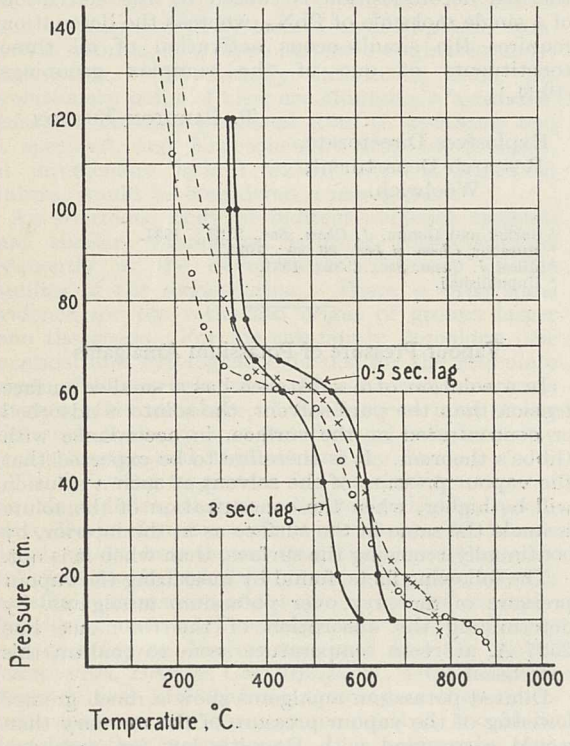

FIG. 1.

the experiment liable to complications from surface effects. It is, therefore, significant that Dixon's results, as shown by the full-line curves in the accompanying illustration (Fig. 1), are of the same general character as those of Neumann and Estrovich, as shown by the broken curves.

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Feb. 3.

[1] NATURE, **133**, 105, Jan. 20, 1934.

The Velocity of Light

IN 1927 there was published in these columns[1] a table of all the determinations of the velocity of light which I compiled from the original memoirs, together with a discussion, and I pointed out that except a pair of practically simultaneous values obtained in 1882 the final values (printed in heavy type) indicate a secular decrease of velocity. The last (and lowest) value given is 299,796 ± 4 km./sec. for 1926.

Since then, two determinations have been made: the first by Karolus and Mittelstaedt (1928) using a Kerr cell, to the terminals of which an alternating potential was applied, for interrupting periodically the luminous beam, instead of a toothed wheel[2]. A frequency can be obtained in this way, of the order of a million per second, which can be accurately calculated, thus permitting a very short base to be used (41·386 metre) without any loss of accuracy. The value found (mean of 755 measurements) was 299,778 ± 20 km./sec. The second recent determination is mentioned in NATURE of February 3, p. 169: it gives for the velocity of light in 1933 the value 299,774 ± 1 or 2 km./sec.

The determinations of this so-called constant made during the last ten years (the most accurate of the whole series) are therefore:

1924	.. ..	299,802 ± 30 km./sec.
1926	.. ..	299,796 ± 4 km./sec.
1928	.. ..	299,778 ± 20 km./sec.
1933	.. ..	299,774 ± 1 or 2 km./sec.

No physicist, looking at the above table, can but admit that the alleged constancy of the velocity of light is absolutely unsupported by observations. As a matter of fact, the above data, treated by Cauchy's method[3], give the linear law:

$$V \text{ km./sec.} = 299{,}900 - 4T \text{ (1900) years.}$$

When I first pointed out this fact (in 1924) it was objected that the data available were inconclusive, because the probable errors of the observations were greater than the alleged rate of change. Sir Arthur Eddington has dealt the death blow to the theory of errors[4] and "this theory is the last surviving stronghold of those who would reject plain fact and common sense in favour of remote deductions from unverifiable guesses, having no merit other than mathematical tractability"[5]. Even "die-hards", however, may fruitfully meditate over the 2nd and the 4th values in the above table.

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[1] NATURE, **120**, 603, Oct. 22, 1927.
[2] *Phys. Z.*, 698–702; 165–167; 1929.
[3] *Engineer*, Sept. 13, 1912.
[4] *Proc. Phys. Soc.*, 271–282; 1933.
[5] Dr. N. R. Campbell, *loc. cit.*, 283.

Graphical Determination of Contemporaries

I REGRET that Mr. Dufton[1] is unable to find in my letter[2] on the above subject any clue as to what I am "trying to do"; others from whom I have heard seem to have had no such difficulty.

The reproduction of Thomas Young's diagram[3] is interesting, but a diagram given by Prof. Raymond Pearl in a paper[4] which he has kindly sent me gives all the information much more clearly and in such a form as to make it of real use to writers and teachers.

There is no ground for the implication made by means of the quotation introduced apparently with this object only, since it is impossible by search to find matter which is quite unrelated to the title of the work in which it is included.

WILLIAM LUCAS.

9 Shanklin Road,
Crouch End, N.8.
March 2.

[1] NATURE, **133**, 381, March 10, 1934.
[2] NATURE, **133**, 141, Jan. 27, 1934.
[3] Young, T., "A Course of Lectures on Natural Philosophy and the Mechanical Arts", London, 1807.
[4] "Tobias Venner and his Via Recta", *Human Biology*, **4**, 568; 1932.

Research Items

Earliest known Miracle Play. Mr. T. H. Gaster describes in *Folk-Lore*, vol. 44, pt. 4, what he believes to be the text of a mumming play or representation in action of a ritual poem from cuneiform tablets found at Ras Shamra. The text, written in a very obscure proto-Semitic dialect, describes a combat between two gods, which it is suggested was recited by priests while a religious pantomime represented the action. As the tablets date from the middle of the second millennium B.C., if this interpretation is correct, this would certainly be the oldest extant text of a miracle play. The text describes what is apparently a ritual combat between summer and winter which is familiar in primitive and popular seasonal ritual from many parts of the world. One of the gods is Aleyan-Baal, god of rains and verdure, and the other Mot or Death, god of aridity and blight. The poem opens at the point where Mot has ousted Aleyan-Baal from his dominion. A new king is chosen and his accession to the throne is described. Through the intervention of Anat, the virgin war goddess, Mot is routed, his royal garments torn from him, he is stabbed and gashed, cast into streams, fished out and finally given dominion over the underworld. Aleyan-Baal is restored, the earth revives, sanctuaries are built in his honour, fires are lit for six days, and sacrifices offered. In Syria, Mot, although corresponding to winter elsewhere, would be the period of drought in the summer, when all vegetation dies, and the return of Aleyan-Baal would take place with the coming of rains in the autumn. It is probable, therefore, that the festival at which the pantomime was performed took place at the 'New Year' in September. The details of the poem correspond with the pattern of the ritual adopted throughout the world in ceremonies of 'Expelling the Death'.

The Alizarin–KOH Method of Staining Vertebrate Skeletons. An abstract of a preliminary note on this subject, by Mr. M. Rahimullah and Prof. B. K. Das, appeared in Nature of February 4, 1933, p. 171. The authors now send their published account (*J. Osmania Univ. Coll.*, Hyderabad, Deccan, 1, 1–3; 1933), illustrated by photographs of successful preparations. There is nothing of importance in this paper that is new, for the method is fairly generally used in Great Britain and in the United States, and adequate accounts are published in Gatenby's edition (1928) of Bolles Lee's "Microtomists Vade-mecum", and in the *Museums Journal*, 28, No. 11, 1929. The *Museums Journal* article, by Peter Gray, states that the alizarin–KOH method is not suitable for small fish. It has, however, been used with success for very small fishes by Parr and by Gloria Hollister in the United States, and by the writer of this note in Great Britain, the process often being complete in a few days. Gray records alternative alcohol-alizarin methods, which are probably more suitable for permanent preparations of larval fishes. He acknowledges his indebtedness to Mr. H. W. Parker of the British Museum (Natural History), who was probably the first to perfect the alizarin–KOH method in Great Britain. To the former abstract of the note of Rahimullah and Das it may now be added that, if the soft parts are to be dissected away from the stained skeleton, care must be taken to avoid excessive maceration in the KOH solutions. A skeleton so prepared must be kept in a sealed jar of fluid (glycerin or xylol is suggested) and is not suitable for handling. The authors emphasise the necessity for prolonged hardening in alcohol before using the KOH solutions.

Burmese Earthworms. In a paper recently received, Mr. G. E. Gates continues his researches on Burmese earthworms, reporting on a large collection which has been carefully gathered from many little-known regions ("The Earthworms of Burma." III. The Megascolecinæ. *Rec. Indian Mus.*, **34**. Part 4. Dec. 1932). 192 pages are taken up with this sub-family alone and there are more than fifty species of the genus *Pheretima*. Interesting facts are shown in *Pheretima alexandri*, which is usually heavily parasitised by both nematodes and gregarines or by large numbers of spherical or ovoid cysts in the anterior portion of the body, especially in the seminal vesicles, the dorsal surface of the pharynx and the dorsal blood vessel, and part of the intestine. It is found that abnormalities occur in these parasitised worms in connexion with secondary sexual characters as distinct from the gonads, the worms being quite normal externally and of the usual size. The author states that the development must have progressed normally up to or nearly up to the time when the secondary organs began to develop, the cause of the abnormalities not being embryological but something that must be looked for in much later stages. The subject is an interesting and important one and would probably lead to valuable results if studied in detail. It is unfortunate that most tropical earthworms can only be obtained in certain seasons; for a considerable portion of the year they cannot be found, the period of drought extending in Burma from November well into June.

Ghost Moths of Australia. The Hepialidæ or ghost moths comprise some of the most archaic of all moths and occur in greater abundance in the isolated continent of Australia than in any other region of the globe. They include some of the most gigantic and also some of the handsomest of known moths, while as caterpillars they are mostly subterranean in habit or form galleries in trees. In order to obtain a true conception of the family, therefore, the Australian forms are of prime importance. Mr. Norman B. Tindale, of the South Australian Museum, has undertaken their revision and the results of his studies are in course of publication in the *Records of the South Australian Museum*. Up to date, Parts 1 and 2 have been issued during 1932 and 1933: these are well illustrated and are accompanied by careful diagrams of the venational and other characters of each genus.

Root and Crown Rot of Peonies. An article on "Control of Crown and Root Rot of Peonies in America" on p. 114 of the *Gardeners' Chronicle* of February 17 summarises a paper by Nellie A. Brown in the American Peony Society's Bulletin. Hot water treatment of peony roots has been used to combat eelworm, but will also control crown and root rot and Lemoine disease. Roots are submerged in water at a temperature of 120° F. for half an hour, but it is advisable to cut out rotten portions so far as practicable. Very severely diseased plants may require treatment in two successive years, but this would disturb the plants more than most gardeners would desire.

The Limits of the Antarctic. The limits of antarctic regions have frequently been discussed. One boundary that has found some acceptance is that of floating ice, which with certain deviations makes the parallel of lat. 60° S. the approximate line. Supan suggested the mean isotherm of 10° C. of the warmest month, but inasmuch as that includes the forests of Fuegia within antarctic regions it is clearly unsuitable. Nordenskjöld, laying greater stress on the mean temperature of the coldest month, found a boundary nearer to lat. 50° S. than 60° S. and excluding all Fuegia. The mapping of the antarctic convergence in the waters of the Southern Ocean by *Discovery II* may furnish the best boundary. This change in water conditions was noted in a recent lecture to the Royal Geographical Society by Mr. Dilwyn Jones. It is the junction of the cold heavy antarctic surface water and the warm but more saline sub-antarctic surface water. The *Discovery* found that it was easily detected in all longitudes by a sharp change in temperature accompanied by corresponding climatic changes, almost equivalent to passing from winter to spring. Biologically, the convergence separates the area of *Euphausia superba* to the south from *E. Valentini* and *E. longirostris* to the north. The line runs for the most part in the latitude of about 50° S. but dips to below 60° S. in the longitude of Cape Horn.

Mexican Earthquake of January 14, 1931. Prof. J. Lacoste has made a careful study of the records of this earthquake (Pub. Bureau Cent. Séis. Intern., Monographs, fasc. No. 5, 3–58 ; 1933), and has prefaced it with a valuable list of 276 Mexican earthquakes during the years 1905–30. The majority of these earthquakes originated in three submarine zones, the centre of the first being in lat. 12·5° N., long. 90° W., of the second and more important in lat. 16° N., long. 97° W., and of the third in lat. 34° N., long. 118° W., all three lying along a band passing through the Acapulco Deep. The earthquake of January 14, 1931, occurred at about 6.55 p.m. and was recorded at all stations throughout the world. The shock, which lasted four minutes, destroyed completely the city of Oaxaca. Prof. Lacoste places the epicentre in lat. 15° 30′ N., long. 96° 25′ W., belonging therefore to the second of the above zones, and lying to the east of the Acapulco Deep, near the isthmus of Tehuantepec. To determine the depth of the focus, he uses Berlage's method based on the interval that elapses between the arrival of the first wave and that of the same wave reflected at the surface. The average of seven estimates is about 45 km. or 27 miles.

New Method of Photographic Photometry. In ordinary photographic photometry, the blackening of the plate is determined by passing a beam of light through the plate and measuring the absorption. A number of microphotometers have been devised for doing this. Brentano, Baxter and Cotton have recently described measurements of the light scattered by the silver particles in the photographic image (*Phil. Mag.* (Supplementary Number), February). In the experiments described, the test plates were made by exposure to X-rays, and for small densities the proportionality between X-ray exposure and scattered light was very close. Much smaller densities may be examined by this method than by absorption microphotometry, and it is therefore interesting to find that no threshold value was found for X-ray exposure before proportionality set in. The method seems very suitable for the photometry of X-ray reflections obtained in the rotation, powder, and Laue examination of crystals, for the proportionality between scattering and exposure enables the photometer to make an automatic integration of the effect over an appreciable area. It seems best to have a fine-grain emulsion and a filtered red light in the scattering photometer, using the light scattered in the range 6°–15°. Scattering from the surface of the emulsion and particularly from scratches is a serious complication, and it was found an advantage to cement a cover glass over the emulsion to reduce this scattering. The authors say that the accuracy obtained may be as good as 0·2 per cent of the limiting blackening for which proportionality can be obtained.

Attempt to Detect a Neutral Particle of Small Mass. Chadwick and Lea have recently published the negative result of an experiment designed to examine the possibility that the continuous β-ray spectrum is accompanied by the emission of penetrating neutral particles (*Proc. Camb. Phil. Soc.*, **30**, Part 1). The energies of these particles might be distributed in such a way that they combine with those of the β-particles to form a constant energy of disintegration, a low energy β-particle being associated with a high energy 'neutrino'. A strong source of radium D + E + F (radium E gives a well-marked continuous β-ray spectrum) was placed near a high-pressure ionisation chamber and an absorption curve was taken with lead screens. The radiation was all identified with the radium E and polonium γ-rays. If neutral particles are emitted, it is calculated that they cannot produce more than 1 ion pair in 150 kilometres path in air. A consideration of the possible nature of the particle shows that, if it exists, it must have small mass and zero magnetic moment.

Movement of Flame in Firedamp Explosions. The Safety in Mines Research Board has recently published Paper No. 82 entitled "The Movement of Flame in Firedamp Explosions" by H. F. Coward and R. V. Wheeler. The paper begins with the simplest type of firedamp explosions and goes on to more complicated cases. The scheme of the paper is that of giving the theory first and then of illustrating it by the results of various experiments. The introduction reminds us that "the lower and upper limits of inflammability of firedamp in air are roughly 5 and 14 per cent of firedamp, and that in a 9·5 per cent mixture, the so-called 'theoretical mixture', the firedamp and oxygen are in the proportions required for their complete combustion on explosion". After considering the general theory the paper goes on to discuss the propagation of flame in plain tubes, first as a uniform motion, secondly as a vibratory motion, and then describes the effects of narrow tubes, perforated plates and other types of constriction. The authors point out that the speed of propagation of a firedamp explosion may vary from zero to approximately 2,000 yd. per second, and the paper concludes with a warning that although a thorough knowledge of the theory of the subject is most helpful in interpreting any colliery explosion, the underground conditions, which in a colliery are usually exceedingly complex, must be thoroughly studied before attempting to apply the theoretical considerations set forth in this pamphlet.

Insect Pests in England and Wales*

A RECENT official report on crop pests in England and Wales covers the years 1928–31 and forms *Bulletin* 66 (1933) of the Ministry of Agriculture and Fisheries. In this publication, Mr. J. C. F. Fryer, director of the Ministry's Plant Pathology Laboratory at Harpenden, reviews the general position over the period mentioned.

In methods of pest control, definite progress is evident with regard to enemies of fruit and other horticultural crops. The English grower to-day, provided he can achieve the desired result, adopts insecticidal measures on a scale as thorough as those employed in the Dominions and the United States. The progressive man realises that, to produce good sound marketable fruit, spraying is not merely an advantage, but is also an absolutely essential part of cultural routine.

In the use of dry sprays or dusts Great Britain is, however, a long way behind. It is nevertheless becoming recognised that they have definite advantages in point of ease and speed of application and reduced costs. Their adoption does not seem likely to come into practice until certain initial difficulties have been overcome. Many of the improvements in control measures have resulted from investigations carried out by members of the Research and Advisory Services of the Ministry of Agriculture. New winter spray fluids have emanated from the Long Ashton Research Station.

Much work has been done in connexion with pyrethrum. It has been shown that this plant can be grown satisfactorily in many parts of England. The problem as to whether the growing of the crops is an economic proposition is now being tried out. At Rothamsted, progress has been made in methods of evaluating the toxic principles found in the pyrethrum flowers. Also, experiments have been conducted with pyrethrum sprays in connexion with horticulture, which show promise, and there is little doubt that considerable developments in this direction are probable.

The entry of foreign pests through the agency of commerce, or other means, forms the second part of this *Bulletin*. During the period under review the apple fruit fly (*Rhagoletis pomonella*) was detected in consignments of low grade apples from the United States. Since it is a serious pest, likely to thrive under English conditions, the Ministry issued the Importation of Apples Order 1930 entirely prohibiting the entry of certain grades of apples from the United States within a specified period each year. Among other immigrant pests the cherry fruit fly, chrysanthemum midge and cottony cushion scale are briefly noticed. Reference is also made to an introduced insect of a beneficial character, namely, the chalcid wasp *Aphelinus mali*. This insect has proved itself at times to be capable of controlling the woolly aphis under English conditions. Whether it is capable of persisting from year to year is very uncertain, and it appears to have failed in many cases owing to unfavourable climatic conditions. It is therefore still doubtful whether this useful parasite can be permanently acclimatised or whether it will need to be reintroduced every few years from colonies grown under protected conditions.

The major part of the *Bulletin* is devoted to a review of the prevalence of each specific crop pest during the four years under consideration. The attacks of cereal and grassland insects, for example, were, on the whole, below the average. Vegetable enemies, especially root flies, caused a good deal of destruction in various parts of the country but the most serious pests were those affecting orchards. Especially injurious were the apple capsid and the apple sawfly. Among strawberry pests the 'red spider' (*Tetranychus telarius*) was very destructive in 1929, when it appeared for the first time in epidemic form: in subsequent years it showed a marked decline. Mention needs also to be made of the great prevalence of the aphis, *Myzus cerasi*, on cherries in Kent which was a feature in 1928: severe infestations also occurred in the south-west of England during 1931.

The *Bulletin* concludes with a useful list of papers published during 1928–31 in various journals and bearing upon subjects dealt with in its pages.

A. D. I.

* Ministry of Agriculture and Fisheries. Bulletin No. 66: Report on Insect Pests of Crops in England and Wales, 1928–1931. Pp. vi+50. (London: H.M. Stationery Office, 1933.) 1*s*. net.

Petrogenesis of the Newry Igneous Complex

IN her paper on "The Eastern End of the Newry Igneous Complex", which was read before the Geological Society on February 7, Miss Doris L. Reynolds made a contribution to petrogenesis of outstanding importance. The rocks described are types common to many orogenic regions, and include peridotite, biotite-pyroxenite, augite- and hypersthene-monzonite, augite-biotite-diorite and granodiorite. These are convincingly shown to be derivatives, not from basaltic or granitic magmas (gabbro and granite being absent from the area), but from three primary sources, two of which have hitherto remained unsuspected. The three parental materials now recognised are (*a*) ultrabasic magmas rich in potash; (*b*) Silurian sediments which became fused by contact with the latter; (*c*) a magma represented almost entirely by plagioclase. The conclusions reached are supported by a suite of detailed analyses made by Mr. L. Theobald and Prof. H. F. Harwood.

The earliest intrusions were peridotite and biotite-pyroxenite, the latter representing a residual magma produced by the abstraction of early-formed olivine and pyroxene from peridotite magma. The ultrabasic magmas rose into graywackes and shales and became surrounded by a zone of selective fusion now represented by a fine-grained massive rock that is seen in all stages of development.

The ultrabasic magmas, which were too dense to rise by stoping, came into place partly by shouldering aside the enclosing sediments, as shown by the way in which the strike lines deviate from the regional Caledonian trend and curve round the contacts, and partly by soaking into the overlying zone of fusion, thus giving rise to augite-monzonite.

Simultaneously with, and also subsequent to, the

intrusion of the ultrabasic rocks, a plagioclase magma invaded and hybridised them with the production of augite-biotite-diorite. The latter rose in turn into the zone of fusion, giving rise to hypersthene-bearing monzonites and diorites.

The granodiorite appears to have risen by stoping, since it is rich in xenoliths of the earlier hybrids and cuts across the sediments in the north-east. In places it transgresses the zone of fusion and contains xenoliths of the fused sediments. Textures and mineral and chemical composition unite in suggesting that the granodiorite is essentially a mixture of sediments and plagioclase magma with a little biotite-pyroxenite. For the most part, it clearly formed in depth and afterwards rose into its present position. The porphyritic granodiorite of Cam Lough Mountain in the west of the Complex represents the simple soaking of plagioclase magma into fused sediments.

An animated discussion followed the reading of the paper. A number of speakers, including Dr. W. Q. Kennedy, Dr. H. H. Thomas, and Mr. W. Campbell Smith, seemed suspicious about the existence of a plagioclase magma, and it was asked whether a granite magma might not be competent to produce the observed results. Miss Reynolds pointed out that since the augite-biotite-diorite is a normatively undersaturated rock almost free from quartz, it is impossible that the addition of granite to the biotite-pyroxenite could have produced it. That the plagioclase came in as a magma is indicated by the observation that it has dissolved all the iron ores with which it has come into contact in the biotite-pyroxenite. From the analyses it was found that the magma is composed of about 80 per cent plagioclase, with iron ores and biotite making up the balance.

Prof. A. Holmes suggested that elsewhere there is ample evidence of plagioclase magma in the existence of anorthosites. Such magma is likely to be very hot, and by syntexis with crustal rocks it would readily grade into syenitic magma, thus providing a wide range of felspathic magmas. Questions of origin are purely speculative, but this does not mean that the plagioclase magma traced by Miss Reynolds is in any way hypothetical; its behaviour and products are demonstrable facts of observation. He welcomed the new light that the evidence from Newry will throw on the less tractable problems of volcanic fields such as that of Bufumbira. The lavas of that region include potash-rich limburgites in which he had recognised the volcanic equivalent of biotite-pyroxenite. Leucite-basanites developed by the incoming of plagioclase, and by the further addition of sialic material latites and hypersthene-trachyandesites were generated.

Prof. A. Brammall pointed out that while the well-known Hollybush diorite of the Malverns might theoretically be referred to the granitisation of greenstones, neither field nor geochemical evidence sustains this view; all the evidence points to a genetic linkage with the biotite-pyroxenite that is present in the area. The formation of the diorite requires the addition to the biotite-pyroxenite of a magma composed of 60 per cent of andesine and rich in iron ores.

As illustrations of other igneous assemblages where there are signs of an ancestry comparable with that of the Newry Complex, Miss Reynolds cited the Loch Ailsh Complex of Scotland, the provinces of Monzoni and Predazzo, the Trondhjemite-Opdalite Series of Norway, the Cortlandt Series of the Appalachians and various examples in the Western Cordillera of North America, including the Rossland Complex described by Daly. She directed attention to the noteworthy fact, hitherto obscured by faulty nomenclature, that true gabbros are characteristically absent from many of the plutonic complexes of folded regions. Referring to the occurrence of monzonites and diorites as individual intrusions, Miss Reynolds suggested that hybridisation, which is known to have taken place at shallow depths, implies more intense activity at greater depths, resulting in the production of actual magmas capable of intrusion to higher levels.

Magnetic Recording and Reproducing in Broadcasting

AT the Paris Universal Exhibition of 1900, Poulsen demonstrated his telegraphone as a magnetic speech recorder for use in a telephone circuit. The apparatus, in its earliest form, consisted of a steel wire or ribbon, which was passed between the poles of an electromagnet, the windings of which were supplied with the audio-frequency currents to be recorded. As the wire was drawn slowly through the field of the magnet, it received therefrom a series of transverse magnetisations corresponding to the sounds received. On the completion of the record, the process could be reversed, and by passing the steel wire between the poles of another magnet connected in series with a telephone receiver, the speech was reproduced.

Various improved forms of the apparatus were developed during the next few years, and among these was one due to Pedersen, who in 1902 succeeded in recording two telephone messages simultaneously on one steel wire, and afterwards reproducing them separately in two receivers. In general, however, the telegraphone, like many other inventions, found little application in connexion with communication technique, until it was given a new lease of life by the introduction of broadcasting.

It is now several years since the Blattnerphone, a modern form of this magnetic recorder, was introduced for recording speech and sections of programmes required for broadcasting purposes. It soon became apparent that the magnetic recording system had important advantages over the use of films or wax discs for this purpose. Among these advantages are the freedom from chemical processes, and from delicate mechanical adjustments, and also the facility with which the recording strip can be 'cleaned-up' for repeated use.

The latest form of this apparatus for commercial use in Great Britain, known as the Marconi-Stille equipment, formed the subject of an article in the *Wireless World* of January 5, and was also demonstrated by Marconi's Wireless Telegraph Company, Ltd. at the recent Physical Society's exhibition. The Marconi-Stille machine provides an uninterrupted record of thirty-five minutes duration; and it incorporates the necessary mechanism for driving the steel tape at a uniform speed through the electromagnetic apparatus, which produces a varying magnetic flux in the tape in the case of recording, or translates the magnetic record into currents of varying amplitude for reproduction purposes. The

steel tape is driven by synchronous motors at a normal speed of 90 metres per minute, between two drums similar to those used in a cinematograph film projector. In its passage the tape passes in succession through three pairs of special bi-polar electromagnets, which are used in turn for 'wiping-out' any previous record, for recording and for reproducing. The heads carrying the two latter sets of magnets are provided with micrometer adjustments for controlling the separation of the pole pieces, since this adjustment affects the response characteristics. The three heads of the apparatus are connected by screened twin leads to their appropriate places on the amplifying and control panels, and means are provided for obtaining the correct level required for recording and reproduction. The recording magnet is also supplied with auxiliary direct current to operate the tape at the best part of the magnetisation characteristic for recording. A suitable audio-frequency correcting circuit is connected in the reproducing amplifier, and the proximity of the recording and reproducing heads on the apparatus enables an instantaneous comparison to be made between the input signals and the output from the equipment.

The magnetic record, once made, is permanent and may be utilised any number of times until it is wiped out by the demagnetising process for use on another programme. The whole process now finds widespread application in broadcasting services, particularly for the relaying of important or interesting programmes at different times.

University and Educational Intelligence

CAMBRIDGE.—J. Yudkin, of Christ's College, has been appointed to the Benn W. Levy research studentship in biochemistry.

Smith's prizes have been awarded to the following candidates: K. Mitchell, of Peterhouse, and A. J. Ward, of Emmanuel College.

Rayleigh prizes have been awarded to M. S. Bartlett, of Queen's College, and C. G. Pendse, of Downing College.

Grants from the Worts Fund have been made as follows:—£50 to N. Bachtin towards the expense of a journey to North Thessaly, £50 to I. H. Cox towards his expenses as geologist in the Parry Islands, £50 to J. J. Keigwin towards the expenses of an expedition to the Zambezi Valley, £50 to P. W. Richards towards the expense of a botanical expedition to South Nigeria, £40 to W. Graham-Smith for palæontological investigations in Canada, £25 to C. W. Borgmann for metallurgical research in Sweden, £25 to J. W. S. Pringle towards the expenses of the Cambridge Freshwater Biological Expedition to South Morocco, £10 to J. W. Welch for expenses in connexion with his study of the Qaoko tribe.

The managers of the Balfour Fund have made a grant of £50 to C. Forster-Cooper, of Trinity Hall, for researches on the fauna of the Achenarass Quarries.

J. H. Lochhead, of Christ's College, has been nominated to use the University's table at the Zoological Station at Naples from April 1 until September 30, 1934.

LEEDS.—The Vice-Chancellor, on behalf of some two hundred subscribers, presented on March 9 to Prof. Walter Garstang a radiogramophone and a cheque, as a token of appreciation from colleagues, pupils and other friends at Plymouth, Oxford, Lowestoft and Leeds. Prof. Garstang retired from the chair of zoology last year.

LONDON.—The following degrees have recently been awarded: D.Sc.(Econ.) to A. E. Feavearyear (private study) for two published works entitled "The Pound Sterling. A History of English Money", and "Spending the National Income"; and D.Sc. in physics to W. E. Williams (recognised teacher at King's College) for ten works on interferometry.

SHEFFIELD.—The following appointments have been made: Dr. E. J. Wayne, to the chair of pharmacology; Dr. James Clark, to the lectureship in infectious diseases; Mr. H. Laithwaite, as junior research assistant in the Department of Glass Technology.

THE Board of Education is prepared to consider applications for full-time studentships from teachers with at least five years' teaching experience who desire financial assistance to follow courses of advanced study at universities or other institutions at home or abroad. Particulars of the awards and application forms are obtainable from the Board of Education, Whitehall, S.W.1.

Science News a Century Ago

Capt. John Ross Honoured

In 1829, thanks to the generosity of Sheriff Felix Booth, Capt. John Ross had been able to fit out the steam vessel *Victory* for arctic exploration. Ross sailed in May 1829 and returned home in October 1833 in the *Isabella*, the *Victory* having had to be abandoned in the ice. On March 27, 1834, at a Court of Common Council, Ross was presented with the freedom of the City of London. In making the presentation, Sir James Shaw, the Chamberlain of the City, said: "Captain Ross—The City of London have ever been forward in bestowing the honour of their freedom on eminent men who have distinguished themselves in the service of the public. In your person science has been largely and specially indebted for the zeal, public spirit and disinterestedness shown by you in fitting out and taking charge of an expedition, with the patriotic view to the solution of the problem whether a north-west passage existed to the Pacific. For the courage and perseverance which have marked the whole of your proceedings in this hazardous enterprise, and for the admirable skill and address manifested by you, with the blessing of Heaven, in preserving life and health and harmony amongst your brave companions, amidst the privations and hardships of four years' navigation in the Arctic regions;—for these services the Corporation of London have recorded their grateful thanks by presenting you with the freedom of their ancient city in a box of British oak."

J. D. Forbes at Edinburgh

When J. D. Forbes in 1833 was appointed to succeed Sir John Leslie as professor of natural philosophy in the University of Edinburgh, he was not twenty-four years of age and had held no appointment before. When preparing his lectures, he wrote

to Whewell for advice on various points, especially in regard to textbooks, for he felt that the textbooks used at Cambridge would be useless for his class at Edinburgh, owing to the then low state of mathematical knowledge among Scottish students. He consulted Whewell on many points in natural philosophy and mechanics, and towards the close of his first session, on March 29, 1834, wrote to Whewell: "I find the greatest advantage from having been obliged to study these subjects in a way necessary to convey a precise idea of them to others; which I feel that almost no other circumstance would have induced me to spend so much labour upon. . . . A month hence, I shall have finished my course, and then propose to escape for a little relaxation. I shall probably go to London, and hope to see you. I am certainly relieved at having got well through so much of my course. The responsibility I felt was oppressive. But my labours have been more than rewarded by the efforts of my pupils, and the obvious improvement in the method and degree of study which has been the consequence. I have given about twenty lectures to the more advanced, going as far as 'Poisson's Demonstration of the Direct Problem of Central Forces', which, humble as it may appear to you, is a step among us 'hyperborean sages'."

Steam Road Carriages

In the first third of last century, steam road carriages were made by many inventors, including Trevithick, Gurney, Hancock, Church, James, Squire, Maceroni and Dance, and some of the vehicles were used for regular passenger services. Two other pioneers were Richard Roberts and John Scott Russell. A carriage made by Roberts made an experimental trip in December 1833, followed by a second three months later. On March 29, 1834, the *Manchester Advertiser* said, "on Thursday the carriage started from the works in Falkner-street at half-past six in the evening under the guidance of Mr. Roberts, with upwards of forty passengers. It proceeded about a mile and a half up Oxford-road, namely, to near the end of Nelson-street, where owing to an apprehension of a deficiency of water, a sudden turn was made. The breadth of the road at this point was insufficient to allow of free scope for the engine, and about six minutes were occupied in making the turn. The carriage then proceeded back to the works where it arrived without accident just nineteen minutes after starting. The maximum speed on a level was twenty miles per hour." On April 4 the carriage was taken out again, but the trial was stopped through the failure of the boiler tubes.

Of Russell's carriage the *Weekly Dispatch* of March 30 said: "A new steam-carriage [Mr. Russell's] commenced plying between Glasgow and Paisley on Wednesday. The carriage is attended by a supplementary vehicle containing the necessary supply of charcoal and water. The carriage is superbly fitted up, holds six inside and twenty outside passengers, and is hung upon springs, quite free of the boiler and machinery. The boiler is extremely small and occupies the space immediately below the carriage while the boot contains the engines. The boiler is capable of generating steam in twenty minutes. The two engines fourteen horse power each situated above the hind axle are connected with it by cranks working at right angles to one another so as to produce continuous rotary motion."

Societies and Academies

LONDON

Institute of Metals (Annual General Meeting), March 7. G. A. HANKINS and C. W. ALDOUS: Minimum dimensions of test samples for Brinell and diamond pyramid hardness tests. The metals investigated include copper, brass, aluminium and steel. A width of test-specimen of $4\frac{1}{2}$ times the diameter of the impression is satisfactory for accurate Brinell tests. For Brinell tests, the limiting value of the ratio of thickness of test sample to depth of impression for accurate results appears to be a characteristic of the test material; a value of the ratio of 6 is required for mild steel, about 15 for copper and more than 20 for spring steel. For diamond pyramid hardness tests a limiting value of the ratio of test-sample thickness to impression diagonal of $1\frac{1}{2}$ gives results which are practically independent of test-sample thickness except with soft copper and soft brass. I. G. SLATER: Note on the influence of gases in an 8 per cent copper-aluminium alloy on normal and inverse segregation. In a sand-cast ingot, 3 in. in diameter by 3 in., segregation is inverse with very gassy melts but normal with degassed melts. GILBERT RIGG: The diffusion of zinc and iron at temperatures below the melting point of zinc. When clean rolled zinc sheet is heated in close contact with clean iron, diffusion commences at below 300° C. and is fairly rapid at above 380° C.; it proceeds by the formation of cones of diffusion products, which spread out from isolated points where the contact between the metals is most perfect, and gradually penetrate into the zinc and across its surface. Two well-defined layers of diffusion products are formed, a thin layer of constant thickness (about 0·08 mm.) containing about 17 per cent iron being next to the iron, and a thicker layer containing 0–11 per cent iron outside this. On continued heating, the thin layer moves towards the zinc, being continuously converted into the zinc-rich layer; this would seem to indicate that the principal diffusion constituent is the iron. H. G. GOUGH, H. L. COX and D. G. SOPWITH: A study of the influence of the intercrystalline boundary on fatigue characteristics. With the object of studying the process of fatigue in relation to crystalline boundaries, tests under alternating torsional stresses have been made on three specimens of aluminium each consisting of two crystals. The distribution of slip bands showed that the effect of the boundaries on the distribution of stress was extremely slight, each crystal of each specimen behaving as if it alone composed the whole specimen. It appears that the presence of intercrystalline boundaries may considerably strengthen the constituent crystals against fatigue; but that the effect of the boundaries on the distribution or even on the amount of slip is very small. It is probable that the major effect of the boundary may lie in some restriction of strain that it imposes. C. E. PEARSON: The viscous properties of extruded eutectic alloys of lead-tin and bismuth-tin. Elongations up to 2,000 per cent have been obtained in tensile tests employing prolonged loading. An apparatus designed to maintain a constant stress on the test-piece during extension shows that deformation takes place at a uniform rate which is greatest in freshly extruded rods and decreases with age or on annealing. The viscosity is not that of simple liquids, but resembles that shown by some disperse systems in which the viscosity

coefficient is a function of the stress causing flow. The locus of viscous flow is found to be at the intercrystalline boundaries. E. W. FELL: A note on some formulæ concerning viscous and plastic flow in soft metals. In particular, the flow of the metal in a prolonged ball-hardness test is compared with the flow in tensile test-pieces under a constant stress per unit area of cross-section. A. PORTEVIN and P. BASTIEN: Castability of ternary alloys. The ability of a molten metal or alloy to fill a mould completely is termed 'castability'; it can be determined by ascertaining the length of a spiral cast-iron mould filled by the metal under predetermined casting conditions. The castability of a pure metal is a linear function of the difference between the pouring temperature θ and the melting point F; the slopes of the castability $(\theta - F)$ curves vary with the viscosity of the metal. The castability of binary alloys varies with the solidification range and with the mode of crystallisation, being greater when polyhedral crystals separate than when the primary crystals are dendritic. Maximum castability occurs with the eutectic composition and minimum at the limit of solid solubility. The castability of ternary alloys generally varies inversely with the primary solidification range.

PARIS

Academy of Sciences, January 29 (*C.R.*, 198, 409–512). E. JOUGUET: Generalisation of the problem of the refraction of adiabatics. ARMAND DE GRAMONT and DANIEL BERETZKI: A property of triode valves. CHARLES NICOLLE, PAUL GIROUD and MME. HELÈNE SPARROW: The exceptional presence of the murin virus in the urine of rats experimentally infected with this virus. In two experiments out of ninety-three, positive results of infection by urine were obtained. LOUIS ROY: The focal image of stars. MME. HILDA GEIRINGER: A general method of theoretical statistics. FRANCESCO SEVERI: The general theory of correspondences between two algebraic surfaces. PAUL LÉVY: A generalisation of Rolle's theorem. M. HAIMOVICI: Fundamental formulæ in the theory of hypersurfaces of a Finsler space. ROBERT GIBRAT: The solutions of a fairly general class of singular integral equations. JEAN LERAY and ALEXANDRE WEINSTEIN: A problem of conformal representation set by the theory of Helmholtz. PAUL BOISSEAU: New integraphs and differentiators. P. SONIER: Charged and compressed thin plates. E. CRAUSSE: Contribution to the study of the vibration of a metallic tube immersed in a liquid in a transitory state. C. POPOVICI: The analytical explanation of air pockets. W. M. ELSASSER: The equations of motion of a neutron. N. SALTYKOW: The canonical transformation of Lagrange equations on the movement of several bodies. J. ELLSWORTH: The variation of the period of the double system, R. Canis Majoris, with eclipses. Supplementing the theory of Tisserand with the effect of aberration, the spectroscopic and photometric results can be satisfactorily explained. FLORIAN LA PORTE: The use of radiogoniometric bearings at a great distance. E. BARRILLON: Geometry of the vessel. Extension of the metacentric method by the use of metacentric sections. AL. PROCA: The quantic mechanics of photons. Pauli's approximation. L. GOLDSTEIN: The theory of elementary corpuscles. ELIGIO PERUCCA: The conductivity of metallic films in an electric field. Using extremely thin films of gold and platinum, deposited by cathode sputtering on quartz threads, variations of resistance with variations of an external electric field were measured. For certain thicknesses of film the change in resistance amounted to 40 per cent. CH. LAVANCHY: A general method for calculating high voltage electrical networks interconnected in a state of permanent equilibrium. G. CARPENISEANU: The anodic oxidation of the lactic ion to the pyruvic ion. Study of the conditions under which the anodic oxidation of sodium lactate to pyruvate can take place. The yields of pyruvate are always small. LÉON CAPDECOMME: The use of vacuum cells for the comparison of feeble light intensities. GUY EMSCHWILLER: The chemical action of light on vinyl iodide. Vinyl iodide on photolysis gives acetylene, ethylene and iodine as primary products. In the presence of oxygen, besides iodine, formic acid, formaldehyde, glycollic aldehyde, carbon monoxide and dioxide and some acetylene are produced. JEAN LOUIS DESTOUCHES: Theoretical remarks on the emission of corpuscular rays (β-rays or positrons) and on the symmetry between corpuscles and anticorpuscles. L. DOMANGE: The densities of aqueous solutions of hydrofluoric acid. The determinations were made in a gravity bottle of bakelite, a material which was proved to be unattacked by the acid. Data are given for twelve strengths of acid between 5 and 54 per cent. E. CANALS, MLLE. G. CAUQUIL and P. PEYROT: The molecular diffusion of light in liquids. JULES GUÉRON: The hydrolysis of solutions of stannic chloride. R. CHARONNAT and L. DEGLAUDE: The criteria of purity of crystallised digitaline (digitoxoside). The authors regard the specific rotatory power as the best criterion of purity. G. DARZENS and MAXENCE MEYER: New methods of preparation of diethoxyacetone and the β-substituted $\alpha\alpha$-diethylines. MARCEL GODCHOT, MAX MOUSSERON and ROBERT GRANGER: The action of hypochlorous acid on active 1-methyl-Δ_3-cyclohexene. RENÉ JACQUEMAIN: Some tertiary alcohols derived from mesityl oxide. V. LEBEDEFF and G. CHOUBERT: New observations on the minerals of Niari (A.E.F.) basin. L. BARRABÉ: The outcrop of the ancient base of the Petites Antilles in the island of Désirade (Guadeloupe). J. BLAYAC, A. MICHEL-LÉVY and M. THORAL: A basic conglomerate in the Cambrian of the Monts de Lacaune and on the pre-Cambrian age of the granitic formations of the Mendic near Graissessac (Hérault). C. DAUZÈRE and J. BOUGET: The variations of the conductivity of the air in caves. Although the temperature and hygrometric state of the air in caves remain very nearly constant, the electrical conductivity of the air undergoes variations of considerable amplitude. J. GAUZIT: The study of the atmospheric ozone at the Pic du Midi by direct vision of the sun at the horizon. The data given were based on spectrophotometric observations. HUBERT GARRIGUE: The radioactivity of the air of the house at the Observatory of the Pic du Midi. LÉON LEMMEL: The spectroscopic study of the wood of the "Pino Sylvestre" of Rascafria (Spain). In addition to the elements which would be expected, the presence of boron, lead and silver was proved. GEORGES DEFLANDRE: The existence on the flagellæ of lateral or terminal filaments (mastigonemes). HERBERT H. JASPER and ANDRÉ PEZARD: The relation between the rapidity of a striated muscle and its histological structure. J. VELLARD, OSWINO PENNA and MIGUELOTE VIANNA: The comparative action of the poisons of *Lachesis atrox* and of *Naja tripudians* in experimental sarcoma in the rat. P. BRUÈRE: Proportions and distribution of manganese in the

grain of wheat. THÉODORE POSTERNAK: A hexose phosphoric acid obtained by the hydrolysis of starch. G. RAMON and E. LEMÉTAYER: Infectious anæmia of the horse. MARCENAC: The anthelmintic power of certain chlorine compounds of butane in cylicostomosis of the horse. Dichlorbutane and chlorobutene have powerful anthelmintic properties and possess advantages over other products usually prescribed for the treatment of cylicostomosis of the horse.

COPENHAGEN

Royal Danish Academy of Sciences and Letters, Oct. 20. TH. MORTENSEN. The marine fauna of St. Helena. It is demonstrated through the study particularly of the echinoderms, based on collections made during investigations at St. Helena in 1929, that the marine fauna of the island originated from three different sources: North Africa–Mediterranean, West Indies –Brazil, and South Africa–Indian Ocean, the various forms having been transported to the island by means of currents, either as pelagic larvæ or as adults, on floating Algæ. The island has never been in connexion with either Africa or South America. The statements of the existence of manatees at St. Helena in recent or pleistocene times—which would seem to prove the existence of former land-connexion —rest on misapplication of the name 'manatee' to sea-lions (see also NATURE, March 17, p. 417).

November 17. JOHS. LINDHARD: The so-called muscle action current experiments on individual muscle fibres show that the action current does not occur when separate fibres are directly stimulated. On the other hand, when the motor end plates are directly stimulated, whether in normal combination with undamaged muscle fibres, or separated from the main mass of fibres, the action current occurs.

December 2. HARALD BOHR: The uniform convergence of Fourier series. A general theorem concerning integration of exponential-polynomials.

January 12. ELIS STRÖMGREN: The use of purely mathematical and of numerical methods in the problem of three bodies.

Forthcoming Events

Monday, March 26

VICTORIA INSTITUTE, at 4.30.—G. R GAIR: "The Cradle of Mankind".

ROYAL GEOGRAPHICAL SOCIETY, at 5.30.—"A Survey Ship on the Coast of Labrador" (Geographical Film).

Tuesday, March 27

ROYAL AERONAUTICAL SOCIETY, at 6.30.—Annual General Meeting.

ROYAL SOCIETY OF ARTS, at 4.30.—Miss Margery Perham: "Some Problems of Indirect Rule in Tropical Africa". (Joint Meeting with the African Society.)

Wednesday, March 28

ROYAL METEOROLOGICAL SOCIETY, at 5.30.—Prof. W. Schmidt: "Micro-Climatological Work in Austria".

Official Publications Received

GREAT BRITAIN AND IRELAND

University of Leeds. Twenty-ninth Report, 1932–33. Pp. 160. Publications and Abstracts of Theses by Members of the University during Session 1932–33. Pp. 31. (Leeds.)

Ministry of Health: Advisory Committee on the Welfare of the Blind. Handbook on the Welfare of the Blind in England and Wales. Revised edition. Pp. iv+50. (London: H.M. Stationery Office.) 1*s*. net.

Empire Cotton Growing Corporation. Reports received from Experimental Stations, 1932–1933. Pp. xi+234. (London: Empire Cotton Growing Corporation.) 2*s*. 6*d*.

The Scientific Proceedings of the Royal Dublin Society. Vol. 21 (N.S.), No. 5: The Oxidation of Hydrazine by Potassium Ferricyanide, Part 1: The Influence of Gaseous Supersaturation on the Measurement of Reaction Velocity; Part 2: The Reaction in Presence of Acetone. By Thomas Norman Richardson and Dr. Kenneth Claude Bailey. Pp. 43–56. (Dublin: Hodges, Figgis and Co.; London: Williams and Norgate, Ltd.) 1*s*.

Ministry of Health. Report to the Minister of Health by the Departmental Committee on Qualifications, Recruitment, Training and Promotion of Local Government Officers. Pp. 91. (London: H.M. Stationery Office.) 1*s*. 6*d*. net.

The National Institute of Agricultural Botany. Fourteenth Report and Accounts, 1932–33. Pp. 19. (Cambridge.)

OTHER COUNTRIES

Canada: Department of Mines: Mines Branch. Anthracite and Coke Analysis Survey conducted at the Fuel Research Laboratories. (No. 737–5.) Pp 13. (Ottawa: King's Printer.)

Commonwealth of Australia: Council for Scientific and Industrial Research. Pamphlet No. 47: Properties of Australian Timbers. Part 1: Eight Timbers of the Genus *Eucalyptus* (Ash Group). Collated and edited by H. E. Dadswell. (Division of Forest Products: Technical Paper No. 13.) Pp. 28+10 plates. (Melbourne: Government Printer.)

U.S. Department of the Interior: Geological Survey. Water-Supply Paper 727: Surface Water Supply of the United States, 1932. Part 2: South Atlantic Slope and Eastern Gulf of Mexico Basins. Pp. vii+221. 15 cents. Water-Supply Paper 731: Surface Water Supply of the United States, 1932. Part 6: Missouri River Basin. Pp. x+349. 20 cents. Water-Supply Paper 733: Surface Water Supply of the United States, 1932. Part 8: Western Gulf of Mexico Basins. Pp. vi+197. 15 cents. Water-Supply Paper 739: Surface Water Supply of the United States, 1932. Part 12: North Pacific Slope Basins. C: Pacific Slope Drainage Basins in Oregon and Lower Columbia River Basin. Pp. vi+167. 15 cents. (Washington, D.C.: Government Printing Office.)

Cornell University Agricultural Experiment Station. Bulletin 577: The Rate of Photosynthesis of Apple Leaves under Natural Conditions, Part 1. By A. J. Heinicke and M. B. Hoffman. Pp. 32. Bulletin 578: The Effect of Different Planes of Protein Intake upon Milk Production. 2: Further Comparisons of 16-, 20- and 24- per cent Mixtures. By E. S. Harrison, E. S. Savage and S. H. Work. Pp. 12. Bulletin 579: The Diagnosis and Control of Mastitis. By D. H. Udall and S. D. Johnson. Pp. 15. Memoir 150: Biochemistry and Biophysics of the Developing Hen's Egg. 2: Influence of Composition of Air. By Alexis L. Romanoff and Anastasia J. Romanoff. Pp. 36. (Ithaca, N.Y.)

Bergens Museum. Årsberetning, 1932–1933. Pp. 90. Årbok, 1933. Hefte 2: Naturvidenskapelig rekke. Pp. 255+5. (Bergen: A.S. John Griegs Boktrykkeri.)

Fiskeridirektoratets Skrifter, Serie Havundsøkelser (Reports on Norwegian Fishery and Marine Investigations.) Vol. 4, No. 4: On the Age and Growth of the Pollack (*Gadus pollachius* L.) from the Norwegian Skagerrack Coast. By Alf Dannevig and Adolf Sørensen. Pp. 15. Vol. 4, No. 5: Nogen iakttagelser over fiskeyngel i trålfangster i Barentshavet. Av Thor Iversen. Pp. 12. Vol. 4, No. 6: A Norwegian Fat-Herring Fjord; an Oceanographical Study of the Eidsfjord. By Jens Eggvin. Pp. 22. Vol. 4, No. 7: Torsken og Fiskehavet 1933 (The Cod and the Sea in 1933). Pp. 27+1 plate. (Bergen: A. S. John Griegs Boktrykkeri.)

Science Reports of the Tokyo Bunrika Daigaku, Section B. No. 15: The Herpetological Fauna in the Vicinity of Nikkô, Japan. By Yaichirô Okado. Pp. 159–173. 30 sen. No. 16: Habitat Notes on the Freshwater Pearl-Mussel, *Margaritana margaritifera* (Linné) in Hokkaidô, Japan. By Kazuo Koba. Pp. 175–180. 15 sen. No. 17: Über einige neue Ciliaten aus dem Darmkanal von japanischen Echinoideen (1). Von Mitsuo Uyemura. Pp. 181–191. 20 sen. No. 18: On the Syngamy of some Myxomycetes. By Seiji Abe. Pp. 193–202. 15 sen. (Tokyo: Maruzen Co., Ltd.)

Fiftieth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1932–1933. Pp. 7. (Washington, D.C.: Smithsonian Institution.)

The Parliament of the Commonwealth of Australia, 1932–33. Seventh Annual Report of the Council for Scientific and Industrial Research for the Year ended 30th June 1933. Pp. 87. (Canberra: Commonwealth Government Printer.) 3*s*. 8*d*.

CATALOGUES

Special Sale Catalogue of Important Journals and Periodicals (Scientific, Technical, Medical, Economic). Pp. 20. (London: Oppenheim and Co. (Rare Books), Ltd.)

Periodica, Iconographiæ, Rara et Curiosa. (No. 85.) Pp. 62. (Berlin: W. Junk.)

A Catalogue of Books and Periodicals on Botany. (No. 485.) Pp. 64. (London: Bernard Quaritch, Ltd.)

Murby's Maps and Models for Geology, including Models of Extinct Vertebrates. Pp. 16. (London: Thomas Murby and Co.)

Bright Annealing by the O.R.P. (Oxide Reduction) Process. Pp. 4. (London: Wild-Barfield Electric Furnaces, Ltd.)

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