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## Industrial Localisation.

DURING recent years close study has been made by the Ministry of Labour, and in other quarters, of labour mobility and transference, and of the various factors entering into the establishment of new industries and the progress or decline of old ones in different localities, matters which may be grouped for convenience under the heading of industrial localisation. This may cover also a comparison of the respective merits of specialist localities, having only one principal industry on which they depend almost wholly for economic life, and diversified localities with several different industries.

A complete discussion of industrial localisation —why a certain trade, or group of trades, settles in one particular locality, why some decline and fall, others are stationary, and others, again, thrive and prosper, of all the varied and complex conditions, indeed, which govern the well-being of industry from the point of view of site selection—this is one of the most important chapters in the economics of industry to-day. No doubt it attracted some attention years ago, at the hands of writers like Marshall, for example; but it has now assumed more than academic importance, and has been well to the fore in most discussions of the dark and intractable problem of unemployment. It is perhaps one of the few avenues where a gleam of hope and light is seen in the far distance.

In approaching unemployment, somewhat wearily at times but yet undaunted, it is of particular interest to note the vital and significant fact that a few districts in Great Britain—one or two of them very extensive—have been much less afflicted with unemployment than the rest of the country. This is doubtless well known to many, but it has been more definitely and clearly demonstrated and set on a more impressive statistical basis by recent investigations than was formerly the case. It is well worth while, however, to consider this matter a little further in its various implications, to inquire a little more closely into the reasons why some parts of the country are so much more fortunate in this respect than others, and, what is of considerable practical importance, to consider whether these favourable conditions can be reproduced elsewhere with similar results on labour demand.

A concrete illustration of fairly successful emergence from the general flood of adversity is afforded by Birmingham and surrounding country.

The incidence or intensity of unemployment may of course be studied by reference to individual trades or individual localities: numerous studies have recently been made of both sorts and a vast amount of statistical material is now available, so that the main issues of the problem are like to be obscured and overwhelmed by a superabundance of such material; but it is difficult to isolate either districts or industries completely, and it is proposed here to consider briefly a large area comprising a great multiplicity of different industries and to examine the suggestions which emerge.

The industrial history of Birmingham and its environs is well known. In 1870 it was mainly engaged in coal-mining, iron manufacture, and numerous hardware trades, but in the great depression which set in about 1874 profound changes took place; many of the older industries declined, some almost to the point of extinction, whilst other new ones took their place, including those connected with the manufacture of bicycles, motor vehicles, and many branches of the rubber, electrical, food, drink, and other trades. The net result is that this part of England has carried out a movement in labour transference on a tremendous scale during the last ten or twelve years—much of it indeed began before the War, so long ago as 1875—and has suffered much less from labour surplus than the rest of the country, with the exception of one or two other areas somewhat similarly circumstanced though on a smaller scale.

The reasons for this are complex and in part obscure, and the usual causes assigned for industrial selectivity are inadequate; or at all events, though we may say that the direct and immediate cause consists in the great diversity of manufactures, it yet remains to ask the reason of this great diversity. It is certainly the case that some areas are specialised and dependent on practically one trade only, and others are diversified and have numerous different trades. Why is this so, and, more particularly, can specialised areas be converted into diversified ones consciously and in accordance with definite planning and co-ordination by Government or other bodies, and thereby reap the same benefits?

The tendency to-day will probably be towards an affirmative reply to the latter query, and it marks a profound change in the modern attitude towards every part of the economic realm. Formerly it was customary, and even regarded as truly scientific and philosophical, to regard economic and industrial phenomena and changes as due to the operation of certain fundamental laws, for the most part inevitable and inexorable: the biological or evolutionary view of society held the field, and governed *inter alia* the localisation of industry. Now we are more disposed to exchange the biological for the architectural and to assert boldly that a nation can consciously build up its economic fabric, going from strength to strength, and perhaps even take some account of beauty in design and form.

The task of construction, however, becomes constantly more difficult and complex, and much, both of the difficulty and complexity, arises from the fact that the political machinery has not even yet been brought sufficiently up-to-date, or inspired with adequate sympathy and knowledge, to realise and deal with the real needs and problems of modern industry. The scientific worker and technologist, it is true, now play a large and prominent part in many departments of government; but this part is still subordinate and the highest ranks of government officials are still dominated by a type of mentality which is certainly not that of the keen alert statesman, trained in business and fully alive to the needs of industry. The political destinies of a great nation have now become so largely dependent on economic and technical factors that it is quite impossible to separate politics from economics: they are now almost one and inseparable, for no industrial problem to-day can be treated apart from its political background and environment.

Reverting, after this brief digression, to the particular aspect of social architecture with which we are dealing, that of industrial localisation, we have found, from the examples of Birmingham and district and one or two other cases, that a diversification of industries—in these cases at least—has reduced the incidence of unemployment. Can we legitimately deduce therefrom a general rule, or is it only applicable in certain narrowly defined areas?

Prof. G. C. Allen, of University College, Hull, in a recent issue of the *Economic Journal*, very ably discusses the particular case of Birmingham and surrounding country, and finds that, where diversified industry is already in existence, it tends to attract additional enterprise and new industries owing to the advantages derived from such variety, among which the chief is that of greater alertness in workers and employers, greater keenness to seize opportunities, and a wider range of technical skill. He does not, of course, suggest that we have here a cure for all industrial ills, that there is no maldistribution of labour, or that all sections of a diversified area are alike benefited: there are, in fact, wide differences even between places not far apart. But he does insist that in this present age—and still more in the future—of rapidly changing technique and industrial development, it is essential to have a far better co-ordinated policy of localisation of new industries, with the twofold object of satisfying the immediate requirements of employers for labour, sites, and materials, and of building up diversified industrial areas which would be less vulnerable in times of change than our specialist centres have shown themselves to be.

It is thus seen that, in industrial areas, as in individuals, specialism may have decided disadvantages, though in both cases it is impossible to ignore the advantages of specialisation. It is, however, easier to suggest more co-ordination than to work out a practical policy to realise it. Yet the opportunities for co-ordination are greater to-day than they have ever been before. Municipal authorities in existing or potential industrial areas, transport organisations, capitalists and leaders of industry, and government representatives have now, or ought to have, wider and better knowledge of each other's needs and endeavours, and many platforms or other facilities for getting together and pushing co-ordinated effort for all it is worth.

The practical questions now are: Where, in this wide realm of ours, are there suitable areas, either of virgin type and new, or already partially industrialised, where new industries can be established? And should we consider Great Britain alone, or the whole of the British Empire? We are inclined to agree with Lord Melchett and take the Imperial view. It seems desirable, too, that agriculture should be included, for this, our greatest industry still, could be used in many ways to add variety to industrial or manufacturing life. Power, especially electrical power, is a vital factor, and therefore the electrification schemes now slowly proceeding could probably be utilised towards better co-ordination in the establishment of new industries.

A further practical help would be for a national body to determine, without unduly fettering individual freedom of choice, the selection of sites, or at least advise thereupon, rather than leave it to the discretion of municipalities and individual manufacturers. This might form part of a general policy of national development, of urban and rural planning, involving co-ordination among many different authorities.

## Genetics, Mathematics, and Natural Selection.

*The Genetical Theory of Natural Selection.* By Dr. R. A. Fisher. Pp. xiv + 272 + 2 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1930.) 17*s.* 6*d.* net.

PROBABLY most geneticists to-day are somewhat sceptical as to the value of the mathematical treatment of their problems. With the deepest respect, and even awe, for that association of complex symbols and human genius that can bring a universe to heel, they are nevertheless content to let it stand at that, believing that in their own particular line it is, after all, plodding that does it. Although it is true that most text-books of genetics open with a chapter on biometry, closer inspection will reveal that this has little connexion with the body of the work, and that more often than not it is merely belated homage to a once fashionable study.

In the preface to his book on "The Genetical Theory of Natural Selection", Dr. Fisher deplores the cleavage between the mathematical and the biological mind, regarding it as due, not to any essential difference in intellectual make-up, but to a difference in the training of the imaginative faculty; and he brings forward an instructive example to illustrate the contrast in the two ways of approaching a problem. "No practical biologist", he writes, "interested in sexual reproduction would be led to work out the detailed consequences experienced by organisms having three or more sexes; yet what else should he do if he wishes to understand why the sexes are, in fact, always two?" To which the biologist, if acquainted with the works of the poet Hoffenstein, might be tempted to reply:

> "Breathes the man with hide so tough
> Who says two sexes aren't enough?"

In spite of Dr. Fisher's view, it is not unlikely that there may be a real genetical difference in the types of mind respectively associated with biological and mathematical thought, so that the matter-of-fact intelligence of the former will seldom be in a position to make much of a response to the imaginative flights of the latter. Nevertheless, it is at times worth the biologist's while to make a special effort, and the present volume offers an occasion; for although Dr. Fisher's mind is essentially a mathematical one, he has marked biological sympathies, and has evidently striven hard to make himself comprehensible to those without the mathematical *flair*. From his book the geneticist will get an idea of the way in which some of his problems are viewed by a detached intelligence; but it ranges over so wide a stretch that it is impossible in a brief review to touch upon more than a few points which seem of special interest to the geneticist, for whose conversion it would appear in some measure to have been written.

That Dr. Fisher's outlook is based upon the assumption of particulate inheritance is only to be expected. Nevertheless, unlike the average geneticist, he does not reject the possibility of blended inheritance as incompatible with the vast corpus of genetical data, but on the ground that to account for such variance as is known to occur, it would demand a mutation rate some thousand-fold greater than does the particulate theory—a rate far greater than we have any grounds for supposing to exist. Yet, although founding his philosophy upon particulate inheritance, he is inclined to deny to mutations any importance in determining the direction of evolutionary change. Moreover, on the analogy of certain experiments dealing with the sensory appreciation of weights, the selective value of the mutation is regarded as in arithmetic proportion to its size, a view to which we fancy few biologists will be willing to subscribe.

Throughout the book one gets the impression that Dr. Fisher views the evolutionary process as a very gradual, almost impalpable one, in spite of the discontinuous basis upon which it works. Perhaps this is because he regards a given population as an entity with its own peculiar properties as such, whereas for the geneticist it is a collection of individuals.

It is a pity that Dr. Fisher, in formulating his views, should not have considered the group of cases of melanistic moths, one of the few in which we have clear evidence of the supplanting of one form by another within a brief period of time. Surely in such cases the mutation can be said to have determined the *direction* of evolutionary change. The marked and unequivocal dominant, as in the case of the successful melanic mutant, is an evident stumbling-block in the way of Dr. Fisher's attempt to reconcile a particulate basis with a continuous process of evolutionary change, and he has considered the matter at some length in a chapter on the evolution of dominance. His explanation in its abstract form is not easy to follow, but fortunately he has illustrated it by the concrete case of the fowl, the domesticated breeds of which are unusual in presenting a number of characteristics dominant to the corresponding ones in the reputed wild progenitor, *Gallus bankira*. Believing that the slightest differences have some selective value, Dr. Fisher sees in the wild type the form of the species most fitted to the environment, and he regards dominance as " a characteristic proper, not to the predecessor as opposed to the successor in a series of mutational changes, but to the prevalent wild type as opposed to its unsuccessful competitors ". Further, he lays down that " the rule which gives genetical dominance to genes of the prevalent wild type requires that the successful new gene should in some way *become* dominant to its competitors ".

Elsewhere Dr. Fisher states that there is no reason for supposing that the mutational process differs under natural conditions from that occurring in the laboratory or the breeding pen. Hence we must suppose that the mutational changes which give rise to dominant characteristics in domestic poultry show little or no influence in the wild form, that is, are either recessive or nearly so. On the accepted basis of particulate inheritance we must suppose that the dominant manifestation of the mutation in one case, and its relative recessivity in the other, are due to a difference in the substratum on which it acts, that is, to a different collection of modifiers in the two cases. Have we grounds, then, for supposing that this substratum differs markedly in the domesticated and in the wild ; and if so, in what way has the change been brought about ? Dr. Fisher suggests that it is due to the peculiar manner in which the fowl has undergone domestication.

It is known that domesticated hens may attract the wild cock and produce fertile offspring from them, and Dr. Fisher considers that at one time the fowl was kept only by jungle tribes, and that the domestic flocks were continually liable to be sired by wild birds. Hens showing some slight difference from the normal, for example, incipient crest, would be likely to be preserved through man's love of novelty. Moreover, owing to the fact that the wild bird was always the sire, these differences could not be of the nature of ordinary recessives. The mutant gene for crest must be regarded as having been brought in by the wild cock, in which it behaved as recessive to its uncrested allelomorph. But owing to a difference in the collection of modifiers in the semi-domesticated hens, it was able to gain some expression. By continually selecting for breeding those hens in which it was most markedly expressed, man was really building up a collection of modifiers which allowed of more and more marked expression, until finally the crested gene was placed on a substratum where its effect was one of unequivocal dominance.

The process should, of course, be reversible, and the transference of the crested gene to what is in other respects a wild *bankira* should result in its becoming a virtual recessive. Dr. Fisher states that experiments on these lines are in progress, and we shall look forward with interest, and some scepticism, to the result. Meanwhile, one need not lose sight of the view that some at any rate of the dominants found in domestic fowls are due to their having had a polyphyletic origin from more wild species of *Gallus* than one. Of the four species known, three have already been shown to give fertile offspring with one another and with domestic races.

Dr. Fisher devotes a chapter to mimicry, rightly perceiving that this is crucial material for the evaluation of any theory of natural selection or of evolution. Denying, as he does, that the mutation or sport can affect the direction of evolutionary change, and being in sympathy with the stock view that natural selection can gradually bring about a condition of adaptation, Dr. Fisher is naturally brought up against Marshall's argument that Müllerian mimicry must be regarded as a special case of Batesian mimicry in that the more numerous species must dictate the nature of the warning pattern. He strives hard, we think unsuccessfully, to get round it; for in doing so he has to postulate an intermediate state enjoying the advantages of both, a very doubtful supposition even allowing that the intermediate state were itself a genetical possibility. But although he seems rather uncomfortable about the way he disposes of Marshall, stating that we "can neither assert that the Müllerian principle will work, nor that it will fail", he nevertheless bases further argument on the assumption that Marshall is wrong. We think that the facts connected with mimicry will repay closer scrutiny on Dr. Fisher's part, for nowhere does there seem to be more cogent evidence for the influence of the discontinuous in evolutionary change.

A considerable proportion of Dr. Fisher's book is devoted to considerations on the evolution of man in his social aspects. He discusses such topics as the decay of civilisations, the mental and moral qualities determining reproduction, the biological aspects of class distinction, the inheritance of fertility, and the decay of ruling classes. He points out that among barbarians the social structure is, as a rule, such that the eminent tend to be the most fertile; whereas in civilised communities social promotion is generally accompanied by infertility. The moral is clear, but the argument is presented in a manner sufficiently detached to avoid that semblance of preaching which is often so boring in works on eugenical reform. Most readers will probably find this the brightest part of the book, for, apart from the absence of mathematical formulæ, it is full of shrewd comments and odd bits of learning. Especially entertaining is the comparison between insect and human communities.

In conclusion, we cannot refrain from a few criticisms of another kind. Dr. Fisher states in his preface that "no efforts of mine could avail to make the book easy reading". That we can well believe. Nevertheless, we feel that he might well have made it much easier reading. The sentences are often unnecessarily long and tortuous, and too often, to make use of a Wellsian phrase, "overlaid with worm-casts of parentheses". Too often the effect of laboriously parsing the sentence in order to grasp its meaning detracts from the necessary effort of comprehension, and the reader feels a just irritation with a writer who might so easily have put it more clearly. As an example, we may give the sentence beginning on line 32 of p. 66, where the word 'to' occurs seven times in various relations. And what are we to make of this other sentence on the same page?—"To postulate equal functional importance of the two homologous genes is therefore not to deny the possibility of all appearance of dominance, but that a general intermediacy of character, such as that to which attention has already been called in heterozygotes between different mutants of the same gene, should be the prevalent condition." This obscurity of diction is the more to be regretted since Dr. Fisher has given us a provocative and stimulating book, and we are left with the feeling that we might have got more out of it if only the style had been terser and more crisp.

R. C. Punnett.

## Size and Form.

*Size and Form in Plants: with Special Reference to the Primary Conducting Tracts.* By Prof. F. O. Bower. Pp. xiv+232. (London: Macmillan and Co., Ltd., 1930). 12*s*. 6*d*. net.

The physiological exchange which is inseparable from active life is conducted through limiting surfaces, external or internal. Provided the form remains unchanged, the bulk of a growing cell, tissue, or organ increases as the cube of the linear dimensions, the surface only as the square. Accordingly, as growth proceeds, the proportion of surface to bulk decreases, until a point of physiological inefficiency is approached. The simple cell solves the problem by division, producing new surfaces along the line of cleavage, but an equally effective solution is provided by appropriate change of form, the fluting or corrugation of the surface, the branching or segregation of the whole structure.

Prof. Bower has emphasised these facts, and has applied them not only to the external surface but also to two other surfaces of physiological transit, the endodermal sheath, where the vascular tracts abut on the surrounding tissue, and the collective surface, where the dead, water-conducting elements of the wood are in contact with living cells. He has the advantage of an unrivalled knowledge of the simplest vascular plants, the ferns and their allies, where the relation of size and form can be studied without the complication of secondary growth. In flowering plants the mass of secondary wood is broken up, interspersed with living cells and traversed by intercellular spaces, so that, in respect of the contact of dead wood elements with living tissue, the needs of increasing size are met without change of outline.

In the sporeling stages of the group of ferns and fern allies, and in the adult stems of its primitive members, the wood elements form a solid column in contact with living cells only on its external surface and lacking intercellular spaces for ventilation. It is here that Prof. Bower has been able to show, by series after series of outline figures, the close association of increasing complexity and increasing size. In the past the relation has often been obscured by the haphazard use of scales of magnification, the enlargement chosen being that which gave a convenient figure, so that the eye was misled. Here, on the contrary, the same magnification is employed throughout a series, and proper emphasis is thereby given to the striking change in size which accompanies development.

In *Psilotum* the young rhizome shows a simple, solid core of wood; as its size increases its outline becomes more elaborate, and it is finally disintegrated into strands surrounding a pith. In a club moss the wood of the sporeling is cruciform as seen in transverse section, in larger axes it is stellate and at last broken into more than twenty radiating strands; in the Cœnopterid group of fossil ferns the surface of the conducting cylinder becomes corrugated and the central cells fail to undergo lignification, forming a columnar pith. In higher ferns the pith is a permanent feature, and great elaboration in the arrangement of the wood is to be found. The endodermal sheath undergoes a similar but less striking series of changes in form, often, as in roots, preserving a circular contour when the outline of the wood is fluted and stellate in section.

Passing to seed plants, Prof. Bower draws an instructive comparison between the wood of the fossil *Sutcliffia* and the larger vascular column of the palms. In *Sutcliffia* the main conducting strand is a continuous mass of wood elements mixed with living cells; it lacks air passages; it is surrounded by similar but smaller strands. Here the contact of wood elements with living tissue is achieved, but the limit of size for an unventilated structure seems to have been reached, and the subdivision of the conducting tissue provides surface through which gaseous exchange can occur. In the well-ventilated vascular column of the palms considerably greater size is attained.

The importance of the relation between size and form is, however, by no means limited to the conducting tissues of vascular plants. Prof. Bower brings under contribution the chloroplasts of the green algæ, showing that these are relatively simple in the smaller species, ridged or flanged in their larger allies; he directs attention to the work of Prof. Hesse on the correlation between the size of the body and the absorptive surface of the gut in the lower Metazoa, and he refers to a number of other zoological examples of the importance of the size-factor in development.

In this book a point of view is elaborated which should both clarify past work and serve to stimulate research.

H. C. I. G.-V.

## Geophysics Pure and Applied.

(1) *Einführung in die Geophysik.* Teil 3: *Dynamische Ozeanographie.* Von Prof. Dr. A. Defant. Pp. x + 222. 18 gold marks. Teil 2: *Erdmagnetismus und Polarlicht, Wärme- und Temperaturverhältnisse der obersten Bodenschichten, Luftelektrizität.* Von Prof. Dr. A. Nippoldt, Dr. J. Keränen, Prof. Dr. E. Schweidler. Pp. ix + 338. 33 gold marks. (Naturwissenschaftliche Monographien und Lehrbücher, herausgegeben von der Schriftleitung der *Naturwissenschaften*, Bände 8 und 9.) (Berlin: Julius Springer, 1929.)

(2) *Die gravimetrischen Verfahren der angewandten Geophysik.* Von Dr. Hans Haalck. (Sammlung geophysikalischer Schriften, herausgegeben von Prof. Dr. Carl Mainka, Nr. 10.) Pp. viii + 205. (Berlin: Gebrüder Borntraeger, 1929.) 16·80 gold marks.

GEOPHYSICS, like her august sister astronomy, is experiencing a new golden age of activity and rapid advance, and in consequence a spate of geophysical books issues from the Press. As with astronomy also, the mode of publication of geophysical work renders the production of works of synthesis and compilation particularly desirable: whereas the researches of physicists and chemists, for example, appear almost exclusively in regular scientific periodicals, which are purchasable through any bookseller, much of the work of astronomers and geophysicists, both on the observational and theoretical sides, appears in the publications of observatories and expeditions, which are often not readily available to private workers, are issued at irregular intervals, and in many cases are not referred to in *Science Abstracts* and similar journals.

The three German books under review are to be welcomed as useful additions to geophysical literature, even where, as in the one dealing with terrestrial magnetism and polar lights, other books on the same subject have recently appeared. While in such cases there is considerable common ground in the different treatments, the divergent interests of different authors, in such wide fields of study, lead to the inclusion by one author of material not mentioned, or only slightly emphasised, by another; the additional facts, views, and references thus made readily available justify the purchase and perusal of the several overlapping works.

(1) Two of the volumes are part of a large collective "Introduction to Geophysics". In the work by Prof. Defant on dynamical oceanography, his aim has been to describe the motion of water in the seas and oceans in the light of the underlying dynamical and physical principles; and in so doing some gaps in the theory have been newly filled in. The part of the subject dealing with waves and tides is treated only briefly, as there is already a considerable literature specially devoted to it. The main theme is the great oceanic circulations and currents, the forces which give rise to them, and the modifications due to the rotation of the earth and the friction and conformation of the oceanic beds and boundaries. The author has given an excellent brief general account of the subject, incorporating much recent work and, by diagrams and otherwise, bringing into close relation with one another the observed facts and the results of research on associated idealised problems. The index of writers quoted in the book illustrates well the author's prefatory remark that, as yet, German workers in oceanography have been few; English, American, and Scandinavian names largely predominate.

In Prof. Nippoldt's admirable brief summary of terrestrial magnetism and polar lights, the space given to the main sections of the subject is as follows: instruments and measurements, 46 pages; the main magnetic field and its secular variation, 63 pages; the transient variations (daily and irregular), 39 pages; and auroræ, 21 pages. In view of the fact that the author is a leading authority on the magnetic distribution and anomalies over Europe, it is natural, and welcome, that this subject is particularly well illustrated and described. The treatment also of other aspects of the subject is clear, concise, and attractive; the diagrams are numerous and well chosen, and the critical accounts of theoretical work, though very brief, are (with few exceptions) excellent.

Prof. Schweidler's interesting summary of atmospheric electricity occupies 91 pages; it will give the non-specialist reader a good general knowledge of the leading problems and results in this field, apart from questions of instruments or measurements, which are not discussed. It is concerned almost entirely with the lower atmosphere, and the Heaviside layer, with its relations to radio transmission and terrestrial magnetism, is not considered.

Dr. Keränen's contribution comprises 122 pages; it relates to a subject which, so far as we know, has not hitherto been summarised in this way. It deals with the intake and emission of heat at and just below the earth's surface, assuming the sun to be the sole source of the heat-changes. The mathematical theory of the subject, so far as it has yet been developed (including that of the downward penetration of periodic temperature variations by thermal conduction), is briefly reproduced. Methods of observation, and the influence of different surface coverings (such as vegetation or snow) on the temperature variations, are carefully considered, and a chapter is devoted to ground frost and its penetration below the surface. Dr. Keränen's account should prove of interest and value to engineers as well as to those concerned mainly with pure science.

(2) The third volume is specially addressed to those wishing to use geophysical science for immediately practical ends. After a brief account of the theory of the gravitational potential (24 pages), and of pendulum observations for the measurement of the direction and intensity of gravity (31 pages), the author proceeds to his main themes; these are the measurement of intensity gradients and of the curvatures of the equipotential surfaces, by means of the Eötvös balance in its various forms (52 pages), the reduction of these measurements (56 pages), and their physico-geological interpretation (38 pages). The volume is a valuable companion to the same author's book on magnetic methods in applied geophysics.

## Our Bookshelf.

*The Art of Retouching Photographic Negatives: and Practical Directions how to finish and colour Photographic Enlargements, etc.* By Robert Johnson. Twelfth edition, revised and rewritten by T. S. Bruce and Alfred Braithwaite. Revised and enlarged by Arthur Hammond. Pp. x + 154 + 16 plates. (London: Chapman and Hall, Ltd., 1930.) 12*s*. 6*d*. net.

That a twelfth edition of Robert Johnson's handbook on the art of retouching has been published is testimony to its excellence and to the fact that progress is constantly being made in the methods and appliances for working up and finishing photographs. The leading professional photographers of the world have so developed their art and their lighting systems that their finished results owe but little to the skill of the retoucher, and their clients are learning to accept the straightforward untouched portrait as a better thing than the old over-retouched ones that former generations demanded. There is, however, still a great majority that demands that their likenesses shall be smoothed out of all semblance of their natural selves, whilst the technical equipment of many photographers is unequal to providing what is required without extensive use of the retoucher's skill. There is also a legitimate demand for skilled retouching in commercial and industrial photography. For these purposes this handbook gives full but concise instructions in the difficult art, but, as the writers confess, success depends rather upon intelligent practice than upon following any printed directions. It is mainly a matter of manual skill wisely directed.

The latest revision of the book is by Arthur Hammond, an associate of the Royal Photographic Society. A comprehensive and painstaking account is given of the materials and methods to be used, of the modelling of each feature of the face, of the working up of backgrounds, etc., of the retouching of landscape, architecture, and animals with pencil, brush, and airbrush. Finally, a series of chapters is devoted to the colouring of photographs by all suitable methods. The whole forms a complete text-book of the retoucher's art based on modern practice. J. Dudley Johnston.

*Sexual Life in Ancient India: a Study in the Comparative History of Indian Culture.* By Johann Jakob Meyer. (The Broadway Oriental Library.) Vol. 1. Pp. xi + 275. Vol. 2. Pp. ix + 277-591. (London: George Routledge and Sons, Ltd., 1930.) 36*s*. net.

The "Broadway Oriental Library", of which this work is one of the initial issue, will meet a very real need if it follows the line suggested in the general introduction. It is primarily intended for those who are interested generally in the results of Oriental studies rather than in their technical and highly specialised details. Oriental studies are at present not well served in this respect, especially as regards India. Much material of the highest value to the student of culture is rendered difficult of access because of the form in which it is cast.

"Sexual Life in India" is an attempt to give an account of the life of women in ancient India based upon the two great epics, the Mahabharata and the Ramayana. It covers the religious and social, as well as the sexual, sides of that life. From this material the author has extracted the most intimate details as to the relation of the sexes. The importance of such matters in the life of the East, and particularly of India, is difficult to overestimate. It gives an orientation to the mind of the East which the West finds difficult to grasp. Prof. Meyer's study is comprehensive within limitations: it deals with the position of the daughter in the family; preparation for marriage; the duties and position of the wife; motherhood; the widow; sexual relations, both regular and irregular, and so forth. But it does not tell the whole story. The material is necessarily, in view of its source, somewhat idealised, and certain sides of sexual life do not come within its purview. This, however, does not detract from the value of the book as a social document. It depicts the theory, if not in all respects the practice, of a certain section of Indian society. For the purposes of this translation, the author has revised the text and added to the notes, to which one of the translators has made further additions.

*The Zeta-Function of Riemann.* By Prof. E. C. Titchmarsh. (Cambridge Tracts in Mathematics and Mathematical Physics, No. 26.) Pp. vi + 104. (Cambridge: At the University Press, 1930.) 6*s*. 6*d*. net.

The function now known as Riemann's zeta-function may be defined as the sum of the $s^{th}$ powers of the reciprocals of all the positive integers from unity to infinity. This definition only holds for a certain range of values of $s$, but it may be generalised, in the usual way, by contour integration. So far back as 1737, Euler had noticed the relation between this function and an infinite product involving primes. No further progress seems to have been made until 1859, when Riemann, in a short paper of only ten pages, indicated a number of ideas which have proved extraordinarily fruitful, and from which many modern researches have developed.

It will surprise those who look upon mathematics as a cut-and-dried science, leaving no scope for imagination and intuition, that an important part of Riemann's work consisted in six theorems which he believed to be true but could not prove. Hadamard at last succeeded with three of these in 1893, while von Mangoldt dealt with two others in 1895 and 1905. The sixth, the famous hypothesis that all the complex zeros have a real part $\frac{1}{2}$, is still unproved.

Prof. Titchmarsh's tract is chiefly devoted to researches produced since Landau's extensive work (1909), but he gives also a brief sketch of earlier work. Some use has been made of an unpublished manuscript by Profs. Littlewood and H. Bohr. The application to the theory of numbers is being dealt with in a companion volume by Mr. A. E. Ingham. H. T. H. P.

## 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.]*

### The Stomatic Control of Transpiration.

THE magnitude of the influence exercised by the stomata in the regulation of the water losses of plants appears to be very different under different conditions.

It has been found that when the mesophyll is rich in water the water loss is largely independent of the stomatic area ('aperture', measured by the porometer) if other conditions are constant.

When a widely open stoma changes in size, the margin of its opening scarcely alters in length. The change in area is due almost entirely to alteration of the length of the short axis.

The following experiment demonstrates that the rate of diffusion of vapour from slit-like apertures is independent of the breadth of the slit (in the case of moderately narrow slits) and is dependent in the main on the length of the slit or of its margin only.

Glass cover slips were cemented over the open ends of a number of cylindrical specimen-tubes leaving approximately rectangular openings, of which the lengths equalled the diameters of the tubes. These tubes were filled with petrol and weighed. The petrol was allowed to evaporate into the air, which may be regarded as a perfect sink for petrol vapour. After ten hours' evaporation the tubes were weighed again ; the losses in weight of the various tubes and the dimensions of the slits through which the evaporation took place are recorded in the table below. The first eight experiments made are shown.

| Expt. | Length in mm. | Width in mm. | Rel. wt. evptd. | Rel. margin. | Rel. area. |
|---|---|---|---|---|---|
| 1 | 11·5 | 0·16 | 100 | 100 | 100 |
| 2 | 10·5 | 0·90 | 97 | 98 | 514 |
| 3 | 11·0 | 1·44 | 103 | 107 | 862 |
| 4 | 11·0 | 1·40 | 116 | 106 | 838 |
| 5 | 10·9 | 3·20 | 100 | 121 | 1897 |
| 6 | 7·1 | 1·18 | 60 | 71 | 452 |
| 7 | 18·3 | 1·20 | 252 | 167 | 1193 |
| 8 | 23·0 | 1·15 | 352 | 207 | 1437 |

From these results it is clear that the breadth of a narrow rectangular opening does not sensibly affect the amount of diffusion through it : in other words, the rate of diffusion through narrow openings is proportional, not to the areas, but to the lengths of the margins of the openings.

It has been pointed out elsewhere (" Transpiration and the Ascent of Sap ", p. 5) that the results of Brown and Escombe may be stated in this manner. However, their observation that the amount of vapour transmitted by diffusion through a circular aperture is proportional to its radius does not account for the fact that, while the closing of widely open stomata is not accompanied by a reduction in transpiration, the final stages of the closing bring about a marked falling off in water loss.

This result is, however, inevitable when we consider that owing to the form of the stomata, during the earlier stages of the closing the margin remains the same length, while, during the final stages, the length of the slit, and consequently that of the margin, is rapidly decreased.

HENRY H. DIXON.
T. A. BENNET-CLARK.

School of Botany,
Trinity College, Dublin, Oct. 4.

### Oviposition of *Hæmatopota pluvialis* Linné.

THE association of tabanid species with their eggs has been determined in only a comparatively few cases. Despite the local abundance of Tabanidæ in tropical, sub-tropical, and temperate countries, the egg-masses and egg-laying habits of many of our common species have consistently escaped the observation of investigators. Not only has the discovery of the eggs in Nature proved elusive, but also frequently the attempts to induce oviposition under controlled conditions in the laboratory have been attended with little or no success. Consequently the biology of many species that have been studied is incomplete. The reasons for this hiatus in our knowledge I have already discussed in a previous paper (" Tabanidæ of the Canadian Prairie ", *Bull. Entom. Res.*, 17 ; 1926). Failure to find eggs has led investigators at various times to suggest that some species may deposit their eggs indiscriminately in the soil instead of ovipositing on the leaves and stems of semi-aquatic plants or on the surfaces of stones in or near water. This hypothesis would appear to be supported by the occasional finding of tabanid larvæ in comparatively dry soil at some distance from water. In western Canada *Tabanus Reinwardtii* Wied. and *Chrysops fulvaster* O.S. are common species, the eggs of which were not found although diligently sought in localities where these species were abundant. It was surmised that the eggs might be laid separately in the soil and thus render their discovery difficult. Both of these species were, however, induced to oviposit in glass jars in the laboratory, when they produced masses similar in all respects to those that are normally laid on leaves by other members of the family.

A survey of the literature of European Tabanidæ shows that the eggs of only two species are known. In 1854 Kollar found the eggs of *Tabanus quattuornotatus* Meig. (" Beitrag zum Haushalten der sehr lästigen Viehbremsen (Tabanidæ) ", *Sitzungsber. d. Akad. d. Wiss.*, Wien, 13), and they were again observed and described by Lécaillon in 1905 (" Sur la ponte des œufs et la vie larvaire des Tabanides, particulièrement du Taon à quatre tâches (*Tabanus quattuornotatus* Meig.)", *Ann. Soc. entom. France*). Two further contributions on the eggs of this species were made by the same author in 1906 (*Compt. rend. Soc. Biol.*, 60) and 1911 (*Ann. Soc. entom. France*, 80). In 1909 Surcouf and Ricardo ("Étude monographique des Tabanides d'Afrique ", Paris) recorded the discovery of the eggs of *T. autumnalis* L. at Lamballe (Côtes-du-Nord) in 1907. Unfortunately, the eggs were not collected when first seen, and on the following day, when a return visit was made, the grass on which the eggs had been deposited was found to have been mown.

Up to the present there is no record of the finding of the eggs of any species of *Hæmatopota*. This is remarkable considering the relative abundance and wide distribution of the genus, of which *H. pluvialis* is our commonest species. In Scotland it is locally very abundant from June to September, and can be readily collected in rural districts where there are ponds and bogs. During July of this year specimens were collected at Threipmuir reservoir, Balerno, near Edinburgh, and were permitted to feed either on the hand and forearm of a human host or on the ear of a rabbit. Some fed immediately the host was presented, and became engorged in ten minutes or less. Others refused to feed after repeated trials from day to day. A female that has partaken of a full blood-meal in the laboratory does not feed a second time, and it is surmised that those specimens which refuse to feed in the laboratory at the first and subsequent trials may have already fed in Nature before they were captured.

Of those that were induced to feed, one deposited a mass of 75 eggs on the walls of a glass jar, in which it was confined, 10 days after engorgement. A layer of moist sand was placed in the bottom of the jar, and into the sand there were stuck the stems and leaves of grasses in an upright position. The escape of the fly was prevented by plugging the mouth with a wad of cotton-wool. In this way the atmosphere in the jar was maintained fresh and slightly humid, and the flies continued to live for two to three weeks. A second fly kept under these same conditions deposited a mass of 125 eggs on the flowering head of perennial rye-grass inside the jar. The accompanying photograph (Fig. 1) shows this second egg-mass. Both

FIG. 1.—Eggs of *Hæmatopota pluvialis* L. on flower of *Lolium perenne*. ×8.

batches of eggs were fertile. Mating probably occurs soon after the adults emerge from the pupæ. In this regard it is interesting to note that a swarm composed entirely of males was observed on the bank of Thriepmuir reservoir on July 19 at 11 A.M. It maintained a position just out of arm's-reach above a chironomid swarm.

The process of egg-laying was carefully observed. The ovipositing behaviour of the fly conforms exactly to that of other tabanid species in which it has been observed (Cameron, loc. cit., 1926). The head of the female is directed downwards, and the abdomen recurved ventrally and anteriorly in the actual laying of the individual eggs. In the interval between the laying of one egg and another, the ovipositor is withdrawn and the abdomen straightened. Each egg, as it is laid, receives a thin coating of cement, which is brushed on by the tip of the ovipositor. This cement is a secretory product of the enlarged, accessory, vaginal glands. The eggs are laid almost vertically to the surface chosen for oviposition, and they remain firmly attached to this and to each other. Having completed one layer the fly proceeds to deposit a second on top of the first. The eggs of this superimposed layer adhere to those of the first end to end. The time occupied in the deposition of the individual eggs averages 15 seconds. They are at first white, but gradually darken to a greyish brown. The egg is cylindrical, tapering slightly to the rounded ends. The average length is 1·612 mm., and the average breadth is 0·29 mm. Hatching occurred in about 10 days under mean daily laboratory temperatures of 60° F. The first instar possesses a prominent, black, sharp-edged, labral, hatching spine, and emerges through a slit, which extends posteriorly for one-third the length of the egg on the antero-dorsal side of the chorion. The cephalic capsule is rudimentary with weak mouth-parts, and is in direct contrast to that of the second-stage larva, which is well developed and resembles in all respects the cephalic capsule of the full-grown larva. The first instar does not feed, but subsists on the occluded yellowish yolk-mass in the mid-gut. Soon after hatching, the first-instar larva moults, and the second instar commences to feed. In the absence of suitable food the second instar will continue to subsist on the remainder of the occluded yolk-mass, and will live unimpaired for four or five days, if kept in a moist atmosphere, without partaking of extraneous food.

A female *H. pluvialis* captured on Aug. 7 fed on a rabbit the same day. This specimen lived in the laboratory for 17 days without ovipositing, when it died. Dissection showed that the ovaries were mature, each containing about 50 eggs.

The investigation of the biology of *H. pluvialis* is to be continued and extended.

A. E. CAMERON.

Department of Zoology,
University of Edinburgh,
Sept. 1.

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### Velocity of Sound in Tubes: Ultra-Sonic Method.

THERE are points still uncertain concerning the velocity of sound in fluids contained in tubes. Relatively little experimental work has been carried out in liquids as the contained fluid, but outstanding is the research of Dorsing (*Ann. der Physik*, **25**, pp. 227-251; 1908), who reported certain cases of *increase* of the velocity as compared with the velocity in the same liquid when unconfined. Generally there is expected a decrease in velocity depending on the diameter of the tube. Unlike most experimenters, Dorsing employed a relatively high frequency in his experiments, about 4000 vibrations per second; so also did Busse (*Ann. der Physik* (4), **75**, pp. 657-664; 1924), who adopted Dorsing's method to determine some useful thermodynamical constants.

Considering the elasticity of the tube wall, corrections to the velocity should be applied for the waste of energy laterally by the vibrations of the wall. No wall is *rigid* to any elastic vibrations, and, in consequence, the wall vibrations (of any type) will cause a damping of the longitudinal vibrations in the contained fluid column. This damping causes a diminution of longitudinal velocity in the column, but generally the diminution is small. The phenomenon has been observed experimentally, and also investigated mathematically, most recently by Gronwall (*Phys. Rev.*, **30**, pp. 71-83; 1927). Pooler (*Phys. Rev.*, **31**, pp. 157-158; 1928) has found an experimental verification of Gronwall's relation by determining experimentally the velocities in a column of liquid contained in a vertical cylindrical steel tube. The vibrations used were of audio frequency, generated by an electromagnetically excited diaphragm at the bottom of the column.

When present-day ultra-sonic methods are applied to the further elucidation of this problem, new and interesting results are disclosed. By using ultra-sonic frequencies, wave-lengths can be employed comparable to the diameter of the column; it turns out that it is then possible to cause at will largely augmented, as well as largely diminished, phase velocities in the liquid of the column—in fact, the velocity-frequency curve is like the selective absorption curve of optics. An actual curve obtained by employing quartz-metal ultra-sonic generators in a glass tube 3·5 cm. in diameter, 57·3 cm. long, wall thickness 2 mm., with naphtha as the contained fluid, is shown in Fig. 1. The frequencies here employed ranged from 25,000 to 74,000 cycles per second, the 'absorption band' appearing between frequencies 34,000 and 40,000 cycles per second. Phase velocities ranged from 0·9 to $2 \cdot 1 \times 10^5$ cm. per sec., the undisturbed velocity being $1 \cdot 35 \times 10^5$ cm. per second.

The experimental method employed was that of stationary waves, the best adaptation so far being an arrangement whereby the positions of the stationary waves could be *seen* by the eye and their breaking up in the frequency range of the absorption band observed visually. Consequently, tubes of transparent materials like celluloid and glass were used, with clear liquids like water, naphtha, chloroform, and oil. Moreover, by taking advantage of the phenomenon of ultra-sonic cavitation, bubbles of gas produced in the liquid by the ultra-sonic vibrations could be made to locate in curtains marking the positions of the nodes of the stationary waves. From the positions of these curtains the measurements of wave-length were taken, from which velocities were computed. It is extremely difficult to get good stationary waves to form, and so permit good determinations of velocity, in the region of frequencies covered by the absorption band.

The best method of generating the stationary waves consisted in the use of two quartz oscillators instead of one, an oscillator being placed at each end of the experimental tube (Fig. 2). These oscillators were made as nearly as possible identical, and were connected in parallel to the oscillating electrical circuit, so that the same frequency and voltage were imposed on each. The positions of the oscillator in the tube were capable of slight adjustment so that the best stationary wave formation could be obtained. But no matter what the method of experiment or what tubes or experimental liquids used, the velocity-frequency curve always had a form like Fig. 1. The same type of experiment carried out at the same frequencies in columns of air only gave the usually anticipated velocity, but no special search for absorption bands was made in this case.

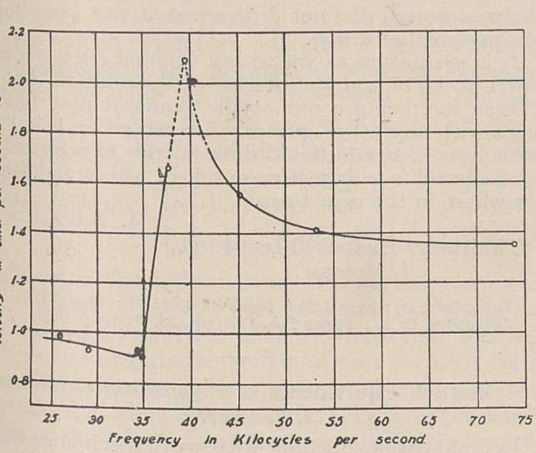


Fig. 1.

All the results obtained on liquids have not yet been analysed, so that it is not yet known with certainty what is the particular form of energy transference which causes this phenomenon; the experiments were of necessity interrupted more than a year ago and are now being resumed.

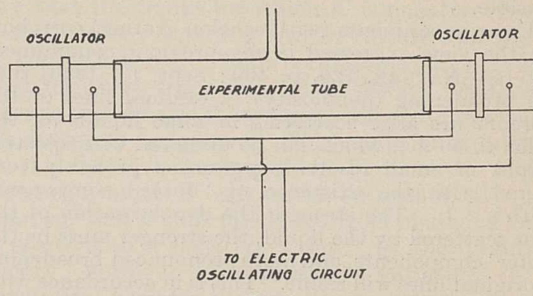


Fig. 2.

R. W. Boyle.
D. Froman.
National Research Laboratories,
Ottawa, Sept. 10.

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**Splitting of the Frequency of Light scattered by Liquids and Optical Anisotropy of Molecules.**

As has already been reported (see Nature, Aug. 9, 1930), the frequency of light scattered by liquids or crystals is split into several components, and their position in the case of strongly scattering liquids like benzene and toluene may be represented by the expression

$$\nu = \nu_0 \left(1 \pm 2n \frac{v}{c} \sin \frac{\theta}{2}\right), \text{ where } n = 0, 1, 2, 3.$$

The study of the polarisation of different components of light scattered by benzene has shown that the central unmodified line and two neighbouring ones, the 'inner' components ($n = 0$ and $n = 1$), are strongly polarised, the electric vector being perpendicular to the direction of incident light. On the contrary, the other, 'outer' components ($n = 2, 3$) are not polarised. Thus the depolarisation of the light scattered by liquids is connected with the presence of the 'outer' unpolarised components. It may, therefore, be supposed that in liquids with large coefficients of depolarisation (strongly scattering liquids) the intensity of 'outer' components is relatively greater than in liquids with small depolarisation (weakly scattering liquids).

In fact, further experiments with carbon disulphide, which possesses optical anisotropy to a high degree, have shown that for this substance 'outer' components are very intensive, being almost of the same intensity as the 'inner' ones. The same may be said of chlorbenzene. On the other hand, for water, ethyl ether, and alcohol, which have very small optical anisotropy, I could not establish with certainty the existence of 'outer' components. Probably they are very weak, and the satellites of the hyperfine structure of the mercury-line (λ4358 A.) prevent their detection.

It may be concluded from these experiments that the existence of 'outer' components is associated with the depolarisation, and the liquids which do not produce depolarisation have not such components.

It may be supposed that the appearance of 'outer' components is due to the diffraction of light, by 'heat-wave lattices' of harmonics, that is, they are produced by lattices with a constant smaller than the half of the wave-length of incident light. In the domain of X-rays such reflections are, as is well known, impossible. It may be that in the case of scattering of light, owing to the depolarisation, they become possible.

These experiments (with echelon grating) corroborate the view expressed in my previous communication [see NATURE, 126, p. 400; Sept. 13, 1930] that the broadening (nebulosity) of original lines of the mercury arc after scattering in some liquids (of the order 40-50 A.), which can be observed with spectrographs of small resolving power, is probably connected with the existence of 'outer' components (with $n \gg 3$). The stronger the depolarisation of the light scattered by the liquid, the stronger must be the 'outer' components, and more pronounced broadening of original lines will result. This is in accordance with the observations of Raman and Krishnan (NATURE, 122, p. 882; 1928), and my own unpublished experiments with a spectrograph of moderate dispersion, that this broadening of scattered lines is connected with the optical anisotropy of the molecules of the liquid.

If the above explanation is correct, the broadened lines must have a definite boundary the position of which corresponds to the greatest possible frequency $\nu_{max.}$ of the Debye 'acoustic spectrum', and therefore must depend for various liquids upon the velocity of sound and the distance between molecules. Experiments now in progress seem to support this view.

E. GROSS.

Optical Institute,
Leningrad, Sept. 8.

## Energies of the C - I and C - Br Bonds.

THE absorption spectra of methyl, ethyl, and isoamyl iodides consist, in the near ultra-violet, of broad continuous bands, with maxima at about 2550 A., and at high vapour pressures, a fairly well defined long wave-length limit at 3340 A. Undoubtedly this corresponds to dissociation into an excited iodine atom and an alkyl residue, and the process might be considered analogous to the disruption of hydriodic acid, HI. If we accept Mecke's figure (NATURE, April 5, 1930) for the energy of the C - H bond (115 kcal.) in hydrocarbons, there is very nice agreement between the thermochemical and spectroscopic data for the energy of the C - I bond. Using Berthelot's figures for the heats of combustion of the alkyl iodides, this energy is calculated to be 65 kcal. Allowing for the excitation energy of the I atom (21 kcal.), the spectroscopic figure is 64 kcal.

With ethyl bromide, assuming that the dissociation is of a similar nature, there is not such excellent agreement. The long wave-length absorption limit of $C_2H_5Br$ appears to be 2800 A. Allowing for the excitation energy of the bromine atom (10 kcal.), the energy of the C - Br bond comes out to be 91 kcal., whereas the thermochemical value is 80 kcal. A discrepancy of the same order of magnitude has already been observed in the case of hydrobromic acid, HBr.

In the liquid state the absorption limits are found to alter, though they are no less well defined than in the gas state. If we allow for the molar heat of vaporisation and compare the minimum dissociation energies of the molecules as imagined free from each other's influences in the two states, these energies are 20 kcal. less in the liquid state for the iodides, and 10 kcal. less for ethyl bromide. It is possible that the molecule dissociates when its total energy increase (electronic, vibrational, etc.) is equal to the heat of dissociation. The absence of a rotational quantisation which is apparent with certain liquids is probably a contributing factor to the instability of the molecule on excitation. The mode of dissociation must be different in the liquid and gas states.

In a paper shortly to be published we hope to describe the experimental work from which the above data were obtained.

T. IREDALE.
A. G. MILLS.

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## *Zacyntha verrucosa* Gärtner: Another Plant with Six Somatic Chromosomes.

AMONG many thousands of flowering plants which have been subjected to cytological investigation, there are known only two examples of a chromosome number so low as six in the diploid condition. One of them is the well-known case of *Crepis capillaris* (L.) Wall. (*C. virens* Vill.), first discovered in 1909.[1] The second reported case is *Callitriche autumnalis* L.[2]

After having studied a great many related genera and species I chanced to find an additional six-chromosome species—a distant relative of *Crepis capillaris*. This species is *Zacyntha verrucosa*. Together with *Crepis* it belongs to the chicory tribe of Compositæ—a group of plants which may now be said to be distinguished by the low chromosome numbers of its representatives.

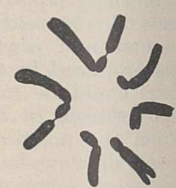

FIG. 1.—Somatic chromosome group of *Zacyntha verrucosa* Gärtner. From a root tip taken from an adult plant. ×2250.

The somatic complement of *Zacyntha* is shown in Fig. 1. From this figure one can see the peculiarity of the largest pair of chromosomes, each of them bearing a large satellite on the proximal short arm. The remaining two pairs exhibit slight although distinct differences of size (especially of their smaller arms).

It is premature as yet to say whether *Zacyntha* will prove to be of genetic interest comparable to that of *Crepis*, for, being a monotypic genus, it may fail to cross with any other species. Investigation is in progress now, and additional data on this new object as well as a full account of its cytology will be published elsewhere in the near future.

M. NAVASHIN.

Timiriazev Biological Institute,
Moscow.

[1] Rosenberg, O.: *Svensk Bot. Tidskrift*, 3, 64-77; 1909.
[2] Jørgensen, C. A.: *Dansk Bot. Tidskrift*, 38, 81-126; 1923.

## English Equivalents of *Eigenfunktion* and *Eigenwert*.

IN publications dealing with wave mechanics there is a growing practice of rendering the words *Eigenfunktion* and *Eigenwert* into English by *eigen-function* and *eigen-value* respectively. The English expressions *proper function* and *proper value* are equally concise, correspond exactly in etymology to the originals, and have the sanction of Prof. Schrödinger himself in the English lectures which he gave at the Royal Institution. Is it not desirable, therefore, that we should discontinue the use of the mixed forms, which is a barbarism without sense or convenience, and equally repellent to German and to English ears?

C. N. HINSHELWOOD.

Trinity College,
Oxford, Sept. 28.

# The Proton.*

By Dr. P. A. M. DIRAC, F.R.S.

MATTER is made up of atoms, each consisting of a number of electrons moving round a central nucleus. It is likely that the nuclei are not simple particles, but are themselves made up of electrons, together with hydrogen nuclei, or protons as they are called, bound very strongly together. There would thus be only two kinds of simple particles out of which all matter is built, the electrons, each carrying a charge $-e$, and the protons, each carrying a charge $+e$.

It should be mentioned here that there is a difficulty in this point of view provided by the nitrogen atom. One can infer from the charge and mass of the nitrogen nucleus that it should consist of 14 protons and 7 electrons, but it appears to have properties inconsistent with its being composed of an odd number of simple particles. However, very little is really known about nuclei, and the opinion is generally held by physicists that some way of evading this difficulty will be found and that all nuclei will ultimately be shown to be made up of electrons and protons.

It has always been the dream of philosophers to have all matter built up from one fundamental kind of particle, so that it is not altogether satisfactory to have two in our theory, the electron and the proton. There are, however, reasons for believing that the electron and proton are really not independent, but are just two manifestations of one elementary kind of particle. This connexion between the electron and proton is, in fact, rather forced upon us by general considerations about the symmetry between positive and negative electric charge, which symmetry prevents us from building up a theory of the negatively charged electrons without bringing in also the positively charged protons. Let us examine how this comes about.

The energy $W$ of a particle in free space is determined in terms of its momentum $p$ according to relativity theory by the equation

$$W^2/c^2 - p^2 - m^2c^2 = 0,$$

where $m$ is the rest-mass of the particle and $c$ is the velocity of light. This equation can easily be generalised to apply to a charged particle moving in an electromagnetic field and can be used as a Hamiltonian to give the equations of motion of the particle, and thus its possible tracks in space-time.

Now the above equation is quadratic in $W$, allowing of both positive and negative values for $W$. Thus for some of the tracks in space-time the energy $W$ will have positive values and for the others negative values. Of course a particle with negative energy (kinetic energy is referred to throughout) has no physical meaning. Such a particle would have less energy the faster it is moving and one would have to put energy into it to bring it to rest, quite contrary to anything that has ever been observed.

The usual way of getting over this difficulty is to say that the tracks for which $W$ is negative do not correspond to anything real in Nature and are to be simply ignored. This is permissible only provided that for every track $W$ is either always positive or always negative, so that one can tell definitely which tracks are to be ignored. This condition is fulfilled in the classical theory, where $W$ must vary continuously, since $W$ can never be numerically less than $mc^2$ and is thus precluded from changing from a positive to a negative value. In the quantum theory, however, discontinuous variations in a dynamical variable such as $W$ are permissible, and detailed calculation shows that $W$ certainly will make transitions from positive to negative values. We can now no longer ignore the states corresponding to a negative energy and it becomes imperative to find some physical meaning for them.

We can deal with these states mathematically, in spite of their being physically nonsense. We find that an electron with negative energy moves in an electromagnetic field in the same way as an ordinary electron with positive energy would move if its charge were reversed in sign, so as to be $+e$ instead of $-e$. This immediately suggests a connexion between negative-energy electrons and protons. One might be tempted at first sight to say that a negative-energy electron *is* a proton, but this, of course, will not do, since protons certainly do not have negative kinetic energy. We must therefore establish the connexion on a different basis.

For this purpose we must take into consideration another property of electrons, namely, the fact that they satisfy the exclusion principle of Pauli. According to this principle, it is impossible for two electrons ever to be in the same quantum state. Now the quantum theory allows only a finite number of states for an electron in a given volume (if we put a restriction on the energy), so that if only one electron can go in each state, there is room for only a finite number of electrons in the given volume. We thus get the idea of a *saturated* distribution of electrons.

Let us now make the assumption that almost all the states of negative energy for an electron are occupied, and thus the whole negative-energy domain is almost saturated with electrons. There will be a few unoccupied negative-energy states, which will be like holes in the otherwise saturated distribution. How would one of these holes appear to our observations ? In the first place, to make the hole disappear, which we can do by filling it up with a negative-energy electron, we must put into it a negative amount of energy. Thus to the hole itself must be ascribed a positive energy. Again, the motion of the hole in an electromagnetic field will be the same as the motion of the electron that would fill up the hole, and this, as we have seen, is just the motion of an ordinary particle with a charge $+e$. These two facts make it reasonable to assert that *the hole is a proton*.

* Based on a paper read before Section A (Mathematical and Physical Science) of the British Association at Bristol on Sept. 8.

In this way we see the proper rôle to be played by the negative-energy states. There is an almost saturated distribution of negative-energy electrons extending over the whole of space, but owing to its uniformity and regularity it is not directly perceptible to us. Only the small departures from perfect uniformity, brought about through some of the negative-energy states being unoccupied, are perceptible, and these appear to us like particles of positive energy and positive charge and are what we call protons.

This theory of the proton involves certain difficulties, which will now be discussed. The theory postulates the existence everywhere of an infinite number of negative-energy electrons per unit volume, and thus an infinite density of electric charge. According to Maxwell's equations, this would give rise to an infinite electric field. We can easily avoid this difficulty by a re-interpretation of Maxwell's equations. A perfect vacuum is now to be considered as a region in which all the states of negative energy and none of those of positive energy are occupied. The electron distribution in such a region must be assumed to produce no field, and only the departures from this vacuum distribution can produce a field according to Maxwell's equations. Thus, in the equation for the electric field $E$

$$\operatorname{div} E = -4\pi\rho,$$

the electric density $\rho$ must consist of a charge $-e$ for each state of positive energy that is occupied, together with a charge $+e$ for each state of negative energy that is unoccupied. This gives complete agreement with the usual ideas of the production of electric fields by electrons and protons.

A second difficulty is concerned with the possible transitions of an electron from a state of positive energy to one of negative energy, which transitions were the original cause of our having to give a physical meaning to the negative-energy states. These transitions are very much restricted when nearly all the negative-energy states are occupied, since an electron in a positive-energy state can then drop only into one of the unoccupied negative-energy states. Such a transition process would result in the simultaneous disappearance of an ordinary positive-energy electron and a hole, and would thus be interpreted as an electron and proton annihilating one another, their energy being emitted in the form of electromagnetic radiation.

There appears to be no reason why such processes should not actually occur somewhere in the world. They would be consistent with all the general laws of Nature, in particular with the law of conservation of electric charge. But they would have to occur only very seldom under ordinary conditions, as they have never been observed in the laboratory. The frequency of occurrence of these processes according to theory has been calculated independently by several investigators, with neglect of the interaction between the electron and proton (that is, the Coulomb force between them). The calculations give a result much too large to be true. In fact, the order of magnitude is altogether wrong. The explanation of this discrepancy is not yet known. Possibly the neglect of the interaction is not justifiable, but it is difficult to see how it could cause such a very big error.

Another unsolved difficulty, perhaps connected with the previous one, is that of the masses. The theory, when one neglects interaction, requires the electron and proton to have the same mass, while experiment shows the mass ratio to be about 1840. Perhaps when one takes interaction into account the theoretical masses will differ, but it is again difficult to see how one could get the large difference required by experiment.

An idea has recently been put forward by Oppenheimer (*Phys. Rev.*, vol. 35, p. 562) which does get over these difficulties, but only at the expense of the unitary theory of the nature of electrons and protons. Oppenheimer supposes that all, and not merely nearly all, of the states of negative energy are occupied, so that a positive-energy electron can never make a transition to a negative-energy state. There being now no holes which we can call protons, we must assume that protons are really independent particles. The proton will now itself have negative-energy states, which we must again assume to be all occupied. The independence of the electron and proton according to this view allows us to give them any masses we please, and further, there will be no mutual annihilation of electrons and protons.

At present it is too early to decide what the ultimate theory of the proton will be. One would like, if possible, to preserve the connexion between the proton and electron, in spite of the difficulties it leads to, as it accounts in a very satisfactory way for the fact that the electron and proton have charges equal in magnitude and opposite in sign. Further advances in the theory of quantum electrodynamics will have to be made before one can deal accurately with the interaction and see whether it will settle the difficulties, or whether, perhaps, a new idea can be introduced which will answer this purpose.

## Physiological Effects of Work in Compressed Air.

THE average man always finds it surprising that our bodies can support such atmospheric pressures as 100 lb. per sq. in. without the slightest derangement of the delicate structures and processes on which life depends, but that, owing to a secondary effect, the return to normal pressure is accompanied by grave risk. A sojourner in compressed air inevitably soaks up a considerable volume of the nitrogen of the air into simple solution in the tissues and fluids of his body. So long as the pressure is maintained this gas remains hidden and harmless, but any reduction of pressure will drive it out of solution. The critical time in the management of compressed air workers is the period of decompression when they are passing from high air pressures down to the normal. Given time, the blood will carry off the excess gas and discharge it to the atmosphere in the lungs as the pressure falls, but a rapid decompression overloads the blood with excess gas, which bursts out in the form of bubbles and chokes the circulation with froth.

Compressed air is used by engineers to keep back water in sinking the foundations of bridges and in tunnelling under rivers; besides the men engaged in such work, divers using the ordinary rubber dress have to breathe air at high pressures. The joint discussion between the Sections of Engineering and Physiology of the British Association at Bristol attracted leading exponents of practice and theory in both these lines of work. Although divers are fewer in number than tunnel workers and their occupation is of less public importance, most of the recent research and experimental work has been directed to their special circumstances, and those responsible for diving work have been quick to take advantage of any new knowledge. An outstanding example is the action of the British Admiralty in being the first to adopt the entirely novel system for conducting the decompression which was devised by Prof. J. S. Haldane and has since been taken up by most of the navies of the world. Its value for divers has now been established by twenty-five years' experience, and particularly in some recent salvage operations where more than five thousand dives were made at pressures between 50 lb. and 60 lb. per sq. in. without accident.

The circumstances of tunnel workers differ from those of divers in that they have to work much longer shifts under pressure, though the pressures themselves are never so high as those experienced by divers. In times past the mortality among the tunnel and caisson workers from compressed air illness was so heavy that many countries adopted State regulations designed to protect the men by limiting the length of shift and enforcing some sort of gradual decompression. Undoubtedly these regulations have done good, but in the light of modern knowledge and experience they could be improved so as to give greater security to the men while avoiding the costly waste of working time resulting from some of their clauses.

If the civil engineering of the future is going to call for higher pressures than the 40 lb. or 45 lb. per sq. in. that has been the limit hitherto, it is certain that these rules will be found badly wanting, and Sir Ernest Moir in opening the discussion indicated that the time has come for concentrating the available knowledge and experience in producing a rational and practicable code or system for the use of engineers charged with the control and safety of workers in such air pressures. One of the difficulties of the matter is that there is a very great difference in the susceptibility to compressed air illness of different individuals, which at present can only be discovered by trial, so that cases of illness are still to be expected under a system which is quite safe for the average man. Fortunately, a cure is available in 'recompression', which if applied sensibly and at once is certain. Sir Ernest Moir, by his introduction and employment of the 'medical air lock' for applying this treatment, has been the means of saving many hundreds of lives.

Dr. M'Master, who described the latest British experience at the Silent Valley dam of the Belfast waterworks, mentioned many points which seemed to show that secondary factors, such as the temperature and humidity of the workings or a slight vitiation of the air supply, which would be unimportant in diving work, made a marked difference in the number of cases. In the sea we have a continuously graded range of hydrostatic pressures through which the diver can be decompressed as he gradually ascends, but in caisson work the pressures can only be roughly adjusted to the theoretical requirements, so that, though all serious illness was prevented, a good many minor but painful cases of 'bends' had to be treated by recompression, and to cure them it was found necessary to recompress many of the patients to 5 lb. above the pressure at which they had been working (about 35 lb.). This contrasts strangely with experience of divers working at 50 lb. pressure, who when they develop similar symptoms are nearly always cured by recompression to a mere 15 lb. or so, which greatly simplifies and shortens the treatment. But divers, being on board ship, are generally treated immediately the symptoms appear, while men on engineering work may have time to get home before they become ill and then may not present themselves for treatment for some hours. This probably underlies the difference, and the point illustrates one of the difficulties of the engineer; he cannot very well insist on a shift of a hundred men hanging about round the works for an hour or two after they have finished work for the day on the off chance that one of them may develop compressed air illness, but the salvage officer with his handful of divers can easily arrange for there to be no means of getting ashore until the danger period is past.

Mr. Davis, jun., in the course of an interesting review of the history of the subject, described apparatus lately introduced by Messrs. Siebe, Gorman and Co. for very deep diving, including a large steel pressure chamber which is lowered under water so that the diver can enter it on the completion of his job and be hoisted inboard without releasing the air pressure from his body. A long decompression can then be conducted in warmth and dryness instead of under water with much discomfort and fatigue as hitherto, while the ship is free to slip her moorings and get clear or fire blasting charges, which could not otherwise be done until the diver's decompression was finished.

Sir Leonard Hill and Commander Selby spoke of the experimental diving which has been carried out for the Admiralty to more than 300 ft. or 130 lb. pressure, using the Davis decompression chamber and other special devices. One unexpected and rather awkward finding was that, though all the divers were picked men who had been put through a specially searching medical examination, some of them became abnormal mentally (or emotionally as Sir Leonard Hill put it) whilst under this high pressure, and on their return to the surface could remember nothing of what they had been doing before they began to ascend. This effect might be attributed to the high partial pressure of oxygen in pure air when breathed at 130 lb., or to impurities in the air which was actually supplied to the divers, but Sir Leonard Hill has made tests on the same men which satisfy him that neither oxygen nor carbon dioxide is responsible. It seems to be an extreme case of the subtle change in character and behaviour which comes over some men at less high air pressures and is well known to experienced diving officers. Divers affected in this way generally keep fairly quiet on the subject, as they do not wish to be thought excitable or foolish about their work. The steel decompression chamber was employed to great advantage in these experimental dives, but, as Prof. Haldane pointed out in concluding the discussion, the stages of decompression given to the men were not calculated on the principles which have proved so satisfactory hitherto and do not appear to have given sufficient margin of safety. This is a matter which can easily be rectified if necessary without invalidating the ingenious methods and appliances which have been elaborated for this extremely difficult sort of diving.

The Italian divers now working on the wreck of the *Egypt* at a depth of 400 feet have cut out all danger of compressed air illness and the need for a host of hampering precautions by using the Neufeldt and Kuhnke armoured apparatus, which, though flexibly jointed, sustains the enormous hydrostatic pressure of 170 lb. per sq. in. corresponding to that depth and enables the man inside to breathe air at atmospheric pressure. The gain in safety and economy of working time which results is partly offset by a loss of mobility and manual efficiency as compared with a rubber-dressed diver, but this again is compensated by the elaborate grabs and machinery of the salvage ship. The diver on the bottom has become less the working agent and more the eye and brain directing engines which are lowered to him and worked from above. Conceivably some such semi-automatic system of working may develop in caisson and tunnel work, though it does not seem called for with the pressures likely to be used in the near future. None of the speakers expressed any doubt that all serious illness could be prevented by suitable decompression: the real problem is to key these lengthy decompression periods in with the design of the tunnel, the scheme of work, and the system of shifts, so that they may become something less wasteful and unsatisfactory than hours of enforced idleness passed in dismal steel cylinders.

G. C. C. Damant.

## Centenary of the Royal Geographical Society.

The Royal Geographical Society will celebrate on Oct. 21 and the two succeeding days its centenary of inauguration. The Duke of York will open the proceedings on the afternoon of Oct. 21, and delegates from the Société de Géographie, of Paris, and the Gesellschaft für Erdkunde, of Berlin, both of which have already celebrated their centenaries, will present addresses. In the evening, Sir Charles Close, president, Mr. Douglas Freshfield, Sir Francis Younghusband, the Marquess of Zetland, and Dr. H. R. Mill will speak on the history of the Society. On the mornings of Oct. 22 and 23, a series of short papers on "The Habitable Globe" will be read by British and foreign geographers, and in the afternoon of Oct. 23, another series on "Incidents in the History of Exploration" will be read by Lord Lugard, Sir Martin Conway, Sir Francis Younghusband, Sir Halford Mackinder, Col. H. Bury, Mr. J. M. Wordie, and others. The centenary dinner of the Society, at which the Prince of Wales will preside, is to be held on Oct. 23.

Enjoying, on Dec. 31, 1929, the enviable roll of 6369 members, inclusive of 679 women, the Royal Geographical Society emerges from one hundred years of vicissitudes a successful and vigorous English institution. Among our readers there must be some of an earlier generation privileged to retain contemporary recollections of intercourse with intrepid pioneer discoverers who, in their day, lifted the veil in fields of the Society's operations—of, for example, John Rae, Erasmus Ommanney, McClintock, Inglefield, Nares, Leigh Smith; of John Kirk, Grant, Burton, Joseph Thomson. To these elders the centenary proceedings should, for this reason, bring especial interest and point.

Space would not permit notice here of the position of geographical knowledge among the nations at the time of establishment of our home-born organisation. Most of us know, however, that in the early years of the nineteenth century, science was moving definitely towards co-operative effort and in departments—its horoscope was cast that way, though no seer maybe could have forecast our present-day delimitations and specialisation. There sprang into existence new bodies—offshoots of the parent Royal Society—and with each that institution observed terms of amity, though Banks was, perhaps, an unduly obstinate element. Among such were the Geological Society (1807), Institution of Civil Engineers (1818), British Association (1831). As regards individual effort and consequent influence on thought, it is useful to recall that Lyell published the first volume of his "Principles of Geology" in 1830; that year witnessed also the issue of Charles Babbage's argumentative "Reflections on the Decline of Science in England".

Already, however, in the geographical domain, Paris had instituted the Société de Géographie (1821); Berlin, the Gesellschaft für Erdkunde (1828). There was at this period half a world of unknown tracts of land to conquer. All Europe, too, was discussing the achievements of Baron Alexander von Humboldt, traveller and naturalist. This illustrious geographer, welcomed constantly in English philosophical circles, had been elected a foreign member of the Royal Society in 1815, had dined with the men of science at their club in 1817, accompanied by Arago and Biot, visiting them again, with Kater as host, in 1827. Much was to ensue from these movements and international greetings and friendships.

In the last-named year, another London dining club, the Raleigh, composed mostly of men of travelling proclivities, came into being, and it early realised that a British institution for the advancement of geographical science was a necessity. The idea found current expression in the influential *Literary Gazette*. In the issue for May 24, 1828, over the initials "A. C. C.", the following appeared: "This society [*i.e.* the Asiatic] has certainly filled up one great hiatus . . . but there is another almost equally important to supply . . . I allude to the want of a Geographical Society, a want which is the more singular, as our nation has always been, and still is, the very foremost in promoting geographical discoveries. I am convinced that if such an Association were now to be formed it would in a few years become even more eminently useful than the famous society of Paris."

The outcome of various individual efforts and alliances of views was the foundation of our London society, brought about at a public meeting held on July 16, 1830, and under the advantageous and able chairmanship of John Barrow, secretary to the Admiralty. Viscount Goderich was elected the first president. King William IV. became patron, directing that the Society's title should be the "Royal Geographical Society". Further, His Majesty granted an annual donation of fifty guineas to constitute a premium for the encouragement and promotion of geographical science and discovery. Four hundred and sixty names were enrolled, forty-three of whom were naval officers, fifty officers of the army, all the leading statesmen of both political parties, including the Duke of Wellington (then Prime Minister), and men of science eminent in all its branches.

The first president, Viscount Goderich, was not, in strict sense, a geographer, neither had his qualifications, so far as one can be aware, any particular scientific bearing or significance. His interests lay in active politics. Notwithstanding these drawbacks, if indeed they were, he seems to have been considered a good figurehead for a Society that had to make beginnings, and a safe one to start with. Educated at Harrow and St. John's College, Cambridge, he entered the House of Commons as the Hon. Frederick John Robinson, filled various subordinate posts, eventually becoming Chancellor of the Exchequer from 1823 until 1827. Upon Canning's death in 1827, he was raised to the peerage as Viscount Goderich, and was Prime Minister for a short while. At the time of election to the presidency of the Royal Geographical Society he was Secretary for War and the Colonies, and a fellow of the Royal Society. He was created Earl of Ripon in 1833.

The *Gentleman's Magazine*, under date Nov. 14, 1831, provides a lively notice of the Society's inaugural session, held in the rooms of the Horticultural Society in Regent Street. We read:

"The first meeting for the season of the Royal Geographical Society took place, the president, Viscount Goderich, in the chair. The room was very much crowded to witness the presentation of his Majesty's first premium of fifty guineas, placed at the disposal of the Society, to Richard Lander, for his discovery of the termination of the Niger, or Quorra, in the sea. After the secretary had read a long paper by Col. Leach on the very interesting question, 'Is the Quorra the Niger of Antiquity?' the noble chairman stated that the meeting had been made special for two specific objects, both of great importance to the general purposes of civilisation, but more particularly to this Nation. The first was to present, on this, the first occasion on which the Society had to dispose of the bounty of his gracious Majesty, the prize to an individual certainly the most enterprising of those men who had their names recorded in the annals of geographical discovery. He felt convinced all who heard him would agree that the first award placed at the disposal of this Society by their gracious Sovereign could not be more appropriately disposed of, than by conferring it on an individual whose talents, courage, and enterprise had achieved so much for the advancement of science. His lordship then presented Lander, who rose for the purpose from his seat at the noble chairman's right hand, with the first premium. The latter, in a few words returned his acknowledgments and expressed his deep gratitude. The second proposition was to incorporate the African Association with the Society, which was carried."

Here it should be mentioned that the African Association, referred to as merged in the new Society, was formed in 1788, mainly through the efforts of Sir Joseph Banks and Major Rennell. It had a small but select membership, and, as its name would imply, concerned itself with the geography of Africa and with schemes for forwarding exploration in that continent.

In connexion with the first allotment, in 1830, of the Royal premium to Richard Lander, it may be recalled that his pioneer explorations (and those of Mungo Park) are commemorated by an obelisk, erected last year on Jebba Island in the Middle Niger. A tablet bears the following inscription:

"To Mungo Park, 1795, and Richard Lander, 1830, who traced the Niger from near its source to the sea. Both died in Africa for Africa."

The fifth annual premium at the disposal of the Society took the form of a gold medal, and the practice continued. On the accession of Queen Victoria it was resolved to award two gold medals annually: (1) the Founder's medal; (2) the Patron's medal.

For a whole decade after inception, the Society met in the apartments of the Horticultural Society. Thereafter, circumstances necessitated sojourns elsewhere, so that the Society became itself a traveller, seeking, yet not securing, a fixed location where all its functions could be performed under one roof. These peripatetic phases are happily ended. Its house at Kensington Gore, occupied in 1913, offered settled habitation, and a long-cherished scheme for additional buildings has come to fruition. It is gratifying to learn that the structures include a meeting hall with seating for 850 persons; ample library space, worthy of the Society's fine collection of books; with other easements necessary to complete the working scope and social aims of a scientific corporation of this kind.

No reference to the Society would be adequate without testimony to the wonderful and enlightened activity it has consistently displayed in regard to exploration in Africa and in Arctic and Antarctic regions, and help in such undertakings as the successive Mount Everest Expeditions, as well as in others. Scientific men and a vast public are well aware of these services; and, should the lands fail in a measure, there remains the air. Already the Society has encouraged the British Arctic Air Route Expedition by supplying it with "the best instruments it could furnish, and a little of its money".

It remains to add that Admiral Sir William Goodenough has been chosen as the new president in succession to Sir Charles Close, whose term of office ends as the one hundred and first year of the Society begins. Scientific workers generally wish the Society continued prosperity and increased activity in this second century of its existence.

## Obituary.

### Mr. M. A. Giblett.

WHEN in 1924 it was decided to take up again with renewed energy the development of airships, it at once became clear that a prime necessity was a specialised meteorological service devoted entirely to airship problems. What exactly were those problems was not known: weather forecasting was obviously one, but there were others, not yet formulated, connected with the forces present in the atmosphere which would affect largely the success of airship transport. It was therefore necessary to place the new Airship Services Division of the Meteorological Office under an able Superintendent. The man chosen for this responsible post was at the time a relatively junior Assistant Superintendent in the Forecast Division, but a man who had already made his mark by his scientific ability and outstanding personality.

Mr. M. A. Giblett was then only a little more than thirty years old, having been born on July 15, 1894. He had been educated first at Upton School, Slough, and Modern School, Maidenhead, and then at the Universities of Reading and London. Three years as nautical master on the Cadet Ship *Worcester* under Capt. Sir David Wilson Barker were no doubt responsible for his becoming interested in meteorology, and in March 1919 he joined the staff of the Meteorological Office for training preparatory to going out to the British Expeditionary Force in North Russia on meteorological duties. He sailed for Russia at the end of July 1919 and received his commission as 2nd Lieutenant in the Meteorological Section, Royal Engineers, while actually on the voyage. He was stationed at Archangel, but had been there only a few weeks when the British Expedition was withdrawn. He returned to the Meteorological Office and resumed his duties as professional assistant in the Forecast Division in October 1919.

As soon as Giblett received his appointment as Superintendent of the Airship Division, he set to work with great energy to plan and build up the meteorological organisation which was to be an integral part of the Imperial scheme for the development of airships. At first this scheme only visualised an airship route to India. He found an almost unexplored field before him. It is true that at each end of the route there were highly developed meteorological services, but between the shores of India and the east of the Mediterranean there was no meteorological service and no synoptic charts had ever been drawn for these regions. Further, although practically every country in Europe prepares its own synoptic charts, there was no single chart of Europe on a scale sufficiently large to make it possible to study in detail the changes of weather even in Europe as a whole. Giblett therefore set to work to collect from every possible source observations for the whole area embracing the route from England to India, and from these prepared a series of daily weather charts for a whole year. It was a stupendous piece of work, which is not yet entirely finished, but with the aid of these charts it was possible to study the routes open to airships and to calculate in detail the times it would occupy to travel each route in different types of weather.

Although at that time the route to India was the only one on which it was planned to employ the airships, it was necessary to make a preliminary survey of possible airship routes to all parts of the Empire. In 1926 this became an urgent problem, for the Air Ministry wished to place before the Imperial Conference which was held in that year a scheme for the development of Imperial air transport. This scheme was presented to the Imperial Conference in a book, afterwards published, entitled "The Approach towards a System of Imperial Air Communications", in which sections on the meteorological investigation of the England-India route and on the meteorological organisation in connexion with the development and operation of airship services were written entirely by Giblett. This description of possible routes, the necessary ground organisation for meteorology, and the co-operation required between the meteorological services was a remarkable piece of work and received much commendation at the Imperial Conference: it showed a power of planning and organising seldom met with in so young a man and a 'scientist' to boot.

It had by that time become clear that meteorology would play an important if not the chief

(*Continued on p.* 619.)

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## The Electron Theory of Metals.*

By R. H. Fowler, F.R.S.

FROM the point of view of the electron theory, a metal is any solid which is a good conductor of electricity. In attempting to survey roughly the present position of the electron theory of metals, I cannot guarantee that what I say will be everywhere up-to-date, but I shall be satisfied if I can indicate the standing of the theory, as re-established by quantum mechanics.

### The Nature of a Metal and Classical Theory.

One may assume that the electron theory of metals effectively began with Drude. At any rate, the triumphant explanation by his theory of the relationship between electrical and thermal conductivities gave it its first real start. The theory, of course, was based, and is still based, on the simplifying approximation, now fairly well justified, that a metal consists of a number of positive ions—atoms that have lost one or more electrons—more or less permanently resident at the positions required by the lattice structure of the metal crystal, together with the lost electrons free to move about among the positive ions.

The simplest assumption of all, which should be correct for monovalent metals like the noble metals and the alkalis, is that each atom sets loose exactly one electron. The electrons and ions act on one another with the usual Coulomb forces, but to the first approximation the effect of these from the point of view of an electron is to make the interior of the metal an electrically neutral region of roughly constant *positive* potential, such that work must be done to extract an electron and leave it at rest outside in free space at zero potential. Inside the metal, then, to this approximation the free electrons will behave like a perfect gas of uncharged particles of mass $m$, the mass of the electron. In the next approximation we must recognise that there are regularly arranged spots (the ions) where there is a more or less violent deviation from uniformity; classically, a moving electron will suffer collisions at these spots. The electrical resistance of a metal is determined by the rate at which these collisions dissipate the directed momentum in a beam of moving electrons. The mean space rate of dissipation of this momentum, $p$, involves a length which one calls the mean free path $\lambda$,

$$\frac{dp}{dx} = -\frac{p}{\lambda}.$$

The classical theory included in its initial successes even the prediction of conductivities of the right order for not unreasonable values of $\lambda$. But it was ruled out of court by at least one outstanding difficulty, that a perfect gas of one free electron per atom would necessarily contribute $\frac{3}{2}R$ to the specific heat of the metal, that is, 3 calories per gram-atom per degree Kelvin, whereas no comparable contribution is allowable. The vibrations of the massive ions satisfactorily account for the whole (see Fig. 1). There are also other difficulties. The main difficulties could have been turned by supposing that there were only a few free electrons doing all the work; they would then require to have correspondingly long free paths. The surprising effect of small traces of impurity upon conductivity requires these long free paths to be real. But classically it was quite impossible that the free path should be much longer than the atomic spacing in the lattice.

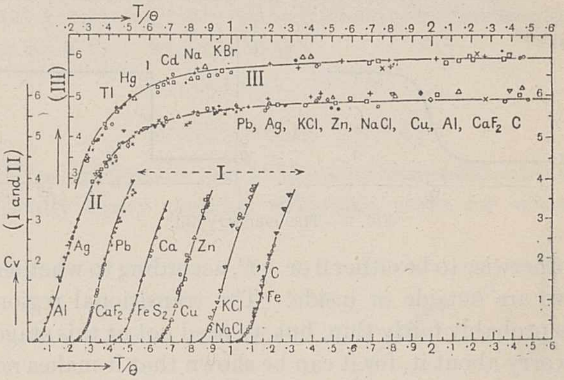


FIG. 1.—The specific heats of various solids as functions of $T/\theta$.

### The Quantum Mechanical Revision.

All these and similar difficulties have been entirely removed by the quantum mechanics using

* An abridged version of the twenty-first Kelvin Lecture delivered at the Institution of Electrical Engineers on May 1.

Drude's model unaltered. In fact, it was the dynamics of electrons, not the physical model of a metal, which was wrong and impeding progress. A recognition of some of the more subtle features of quantum mechanics is required to put us on the right track. Let us therefore make a fresh start by discussing the quantum mechanical behaviour of a single electron in the approximate potential field provided by our model of a metal.

Quantum mechanics assigns to any such system a certain number of possible stationary states the energies of which are fixed by the condition that solutions of a certain linear differential equation (Schrödinger's) shall exist, satisfying certain physically obvious requirements. If $V$ is the potential energy of an electron, $h$ Planck's constant, and $\nabla^2$ the familiar operator of Laplace, then this equation is

$$-\frac{h^2}{8\pi^2 m}\nabla^2\psi + (V - W)\psi = 0$$

and the possible values of $W$ are the possible *total* energies of the electron. Now our picture requires $V$ to vary rapidly near the metal boundary, and

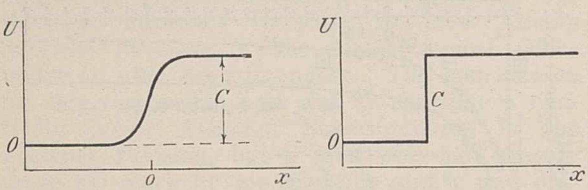


FIG. 2.—The boundary hill.

otherwise to be either 0 or $-C$, according to whether we are outside or inside. The transitional region is probably fairly thin, but we need not at this stage worry about it, for it can be shown that it makes no difference if we take it instead as a sudden step. Again, as this step is fairly high (10 volts or so would be high for present purposes), it makes little difference if we take it infinite. We have then to solve the wave equation

$$-\frac{h^2}{8\pi^2 m}\nabla^2\psi - E\psi = 0,$$

where $E$ is *kinetic* energy, subject to the condition that $\psi = 0$ on the boundary and outside, where $V$ becomes infinitely greater than it is within.*

It is easy to solve this equation if the region within which the electrons are confined is a rectangular box of edges $a$, $b$, $c$. The shape of the box can be shown not to matter for practical applications. For this simple shape the possible kinetic energies are given by

$$E = \frac{h^2}{8m}\left(\frac{r^2}{a^2} + \frac{s^2}{b^2} + \frac{t^2}{c^2}\right)$$

* This is the form to which our physical requirements reduce in such a limiting case.

where $r$, $s$, $t$ are positive integers, and the corresponding function $\psi$ is

$$\psi_{r,s,t} = \sin\frac{\pi r x}{a}\sin\frac{\pi s y}{b}\sin\frac{\pi t z}{c}.$$

We now find, on account of the smallness of $h$ and in spite of the smallness of $m$, that if we take a box of any ordinarily small size, let us say 1 mm.$^3$, or even a cube of edge $\frac{1}{2}\times 10^{-4}$ cm., a wave-length of visible light, the energies of the possible stationary states lie so close together that we cannot distinguish them for practical purposes from the continuous distribution allowed by classical mechanics. If we then pack into such a box a number of electrons comparable with the number of atoms in the same volume of metal, *and if they do not interfere with one another in any way*, we get a distribution of free electrons indistinguishable from the classical (Maxwellian) distribution of Drude's theory—with the same properties and the same failure as a representation of an actual metal.

Here quantum mechanics makes its first really fundamental contribution in this field, as was first pointed out *for metal theory* by Sommerfeld. It is that one can never, even in zero-order approximation—even in the limit of vanishingly small interactions of the particles' mutual potential energy—treat a composite assembly of two or more electrons by simple combinations of the states possible to one electron. This is not at all (at least to the present depth of our analysis) because of the Coulomb repulsion between them. It applies equally in the limit when this may be supposed to be neutralised. It is not because of other forces which might be regarded as giving the electron a *size*. It is something far more fundamental, entering into the quantum dynamics because its equations are all *linear* in the fundamental wave-function $\psi$, and entirely foreign to classical particle dynamics because its equations are essentially non-linear, for example in the momenta. It is mathematically like a species of interference due to the superposition of wave systems, with which we are familiar in ordinary oscillating systems, though this analogy must be used with extreme caution. One is apt to think of the de Broglie wave systems associated with particles by the quantum mechanics as wave systems like electromagnetic waves in the ordinary space-time of physics. But the wave system of a pair of electrons, for example, so far as it is anything describable, is strictly a wave system in a six-dimensional space, and so on for more electrons. Electromagnetic or optical analogies are invaluable, but when we wish to use our results by interpreting them in physical space-time, the greatest caution may be necessary.

Whatever may be the correct physical description, the theory is certainly of such a form that possible states of two or more electrons present in a single box together are confined to a selection only of all the states that can be built up by repetition from the states of a single electron. The proper selection can be simply described by saying that *no two electrons can ever be simultaneously in the same stationary state*. This rule holds for all assemblies of electrons, for example, for a single free atom, for which it was first detected semi-empirically by Pauli. It is generally

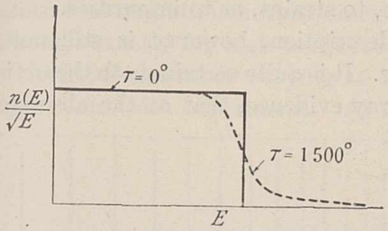


FIG. 3.—The distribution law at 0° and 1500° Kelvin.

now known as *Pauli's principle*. The principle must be strictly interpreted. We shall have to admit later on that electrons have a spin of their own and an associated magnetic moment which is capable of exactly two orientations, along and against any magnetic field. These two orientations may be regarded as the two possible values of another quantum number which, with $r$, $s$, and $t$, makes up four for each electron. The strict enunciation of Pauli's principle is, then, that in any assembly of electrons no two electrons may ever have the same *four* quantum numbers.

I have deliberately stressed the independence of Pauli's principle of any crude mutual potential energy between the electrons. This is the correct and only not misleading attitude to adopt at the present stage of development of the theory. But perhaps if the recent researches of Eddington prove ultimately fruitful, one may hope to fuse together Pauli's principle and Coulomb interactions as two manifestations of a single, more comprehensive scheme.

Quantum mechanics cannot yet predict that electrons will in fact obey Pauli's principle; it can as yet only show that if initially all electrons obey this principle, they will continue to do so for ever. In fact, it seems they always do obey it. As has been said, it was its introduction into metal theory by Sommerfeld that gave metal theory its new start. Allowing for Pauli's principle, we find that the number of free electrons with kinetic energies between $E$ and $E + dE$ in a unit volume of an idealised metal, instead of being given by the familiar distribution law of Maxwell,

$$n(E)dE = A'e^{-E/kT}E^{\frac{1}{2}}dE, \qquad (1)$$

is given by the slightly different law of Fermi and Dirac,

$$n(E)dE = \frac{4\pi(2m)^{\frac{3}{2}}}{h^2}\frac{E^{\frac{1}{2}}dE}{1+e^{E/kT}/A}. \qquad (2)$$

$A$, $A'$ are constants so adjusted that the total number of electrons of all energies is correct—perhaps the equivalent of one per atom for a monovalent metal. It will be noticed that equation (2) reduces to equation (1) when $A$ is very small, but there is no resemblance when $A$ is large. When $A$ is large its value is given approximately by

$$A = e^{\bar{E}/kT}, \quad \bar{E} = \frac{h^2}{8m}\left(\frac{3n}{\pi}\right)^{\frac{2}{3}},$$

where $n$ is the total density of the electrons.

Just here is where the very small mass of the electron takes effect. Obviously, $A$ depends on the mass, and turns out to be large for electron densities of the order of metallic ones, so large, in fact, that the distribution would be quite unclassical even, for example, for copper at 1500° K. This is shown clearly by the actual distribution law sketched by Nordheim in Fig. 3. At ordinary room temperatures, and even well above, the distribution is such that, nearly enough,

$$n(E) \propto E^{\frac{1}{2}} \quad (E < \bar{E}),$$

$$n(E) \propto e^{-E/kT}E^{\frac{1}{2}} \quad (E > \bar{E}).$$

What happens is that at all such temperatures practically every possible electronic state for which

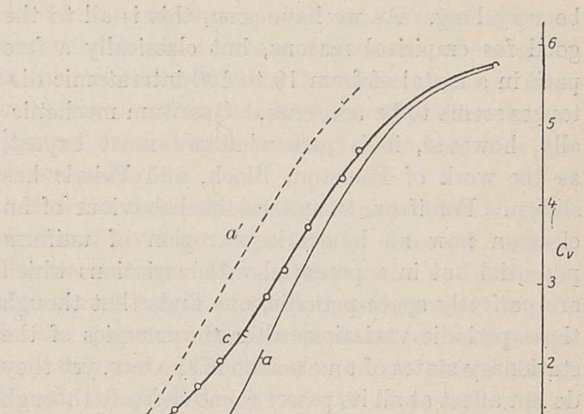


FIG. 4.—Specific heat of grey tin. Circles indicate observed values. Curves $a$ and $a'$ are Debye curves which cannot be made to fit; curve $c$ is $a+b$, and $b$ is here interpreted as the contribution of the electrons.

$E < \bar{E}$ is occupied by its one electron, while for $E > \bar{E}$ practically all are empty. The very few electrons that are there are too few to worry each other, so that they can obey Maxwell's law.

We find at once that the specific heat difficulty melts away. One can see at a glance from Nordheim's figure that the change of energy content with change of temperature must be very small. Detailed calculation confirms this and gives the total kinetic energy, $E_{kin.}$,

$$E_{kin.} = \frac{\pi}{40} \cdot \frac{h^2}{m}\left(\frac{3n}{\pi}\right)^{\frac{5}{3}} + \frac{2\pi^3 m k^2 T^2}{3h^2}\left(\frac{3n}{\pi}\right)^{\frac{1}{3}},$$

from which the specific heat contribution is utterly negligible. It is, in fact, *too* small, and later more refined calculations by Bloch make it rather larger generally and possibly much larger in a limited region, so that it is able to account in a most satisfactory way for certain interesting specific heat anomalies such as have been found by Simon at fairly low temperatures for grey tin (see Fig. 4) and other metals. The constant term, on the other hand, is large; the electrons have a large 'zero point energy'. But this is without importance for metallic phenomena.

### The New Conduction Theory.

We have so far considered equilibrium states only, and have still to apply the new theory to conduction problems, states of steady flow.

In a preliminary survey, Sommerfeld revised Lorentz's calculations by using the new equilibrium $n(E)$ instead of Maxwell's, and showed that to give observed conductivities the mean free paths must be very long. As we have seen, this is all to the good for empirical reasons, but classically a free path in a metal of from 10 to 100 interatomic distances seems to be nonsense. Quantum mechanically, however, it is just what we must expect, as the work of Houston, Bloch, and Peierls has shown. For if one examines the behaviour of an electron now no longer in a region of uniform potential but in a potential with variations which are perfectly space-periodic, one finds that though these periodic variations alter the energies of the stationary states of an electron in the box, yet they do not affect at all its power to move freely through the box in a given direction.

Such perfectly periodic variations of potential can correspond only to a metal which is a perfectly pure, perfect, single crystal at zero temperature, assuming that then all the ions are at rest relative to each other. But in such a substance the mean free path of an electron with a kinetic energy of a few volts should be infinitely long, and the substance should possess an infinite conductivity. One can give an analogy to these long or infinite free paths from physical optics. Light in passing through an optically homogeneous medium such as air or many crystals is to a first approximation not scattered or absorbed at all, though every molecule is a potential scattering centre. As was first shown by the late Lord Rayleigh, it is only local deviations from perfect uniformity that scatter the light; deviations which in a dust-free gas are probably fluctuations of concentration, and in a crystal flaws and foreign bodies. Just so the de Broglie waves of the electron are not scattered by perfectly regular lattices but only by random deviations from perfect regularity, due to thermal agitation, to strains, or to impurities.

This description, however, is still not entirely adequate. It is quite certain, both theoretically and from X-ray evidence, that at the absolute zero of

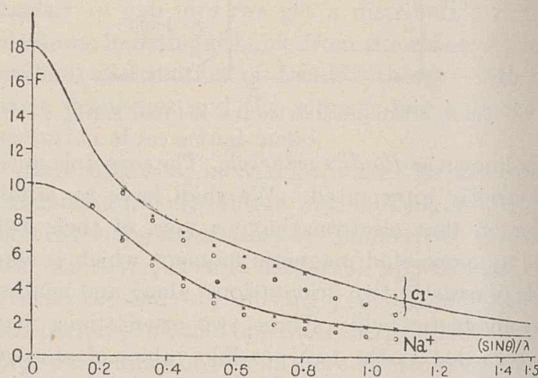


Fig. 5.—Comparison of $F$ values deduced from observation with those calculated from theory. $F$ is plotted as a function of sin $\theta/\lambda$ for $Na^+$ and $Cl^-$ ions; $\theta$=glancing angle; $\lambda$=wave-length in A. Curves show values of $F$ for distribution of charge calculated by wave mechanics. Crosses show values of $F$ deduced from observation, assuming zero point energy; circles show values of $F$ deduced from observation, assuming no zero point energy.

temperature the ions of a metal crystal are not at rest in their positions of equilibrium but oscillating about them, the whole crystal containing a considerable irreducible zero point energy of oscillation. This fact (see Fig. 5), which at first sight appears destructive of the theory, urges a closer investigation, for conductivities certainly tend to infinity in favourable cases as the temperature tends to zero, even if supra-conductivity does not appear. It is then found that one cannot properly discuss the mean free path without investigating in detail the exchange both of energy and momentum between an electron and the lattice, which must occur when a free path is terminated.

One can analyse the motion of the ions in the lattice into elastic waves in the manner of Debye in his theory of specific heats. In order that a free path may be terminated it is necessary—

(1) That an electron of energy $E$ and momentum $p$ shall be transferred to $E'$, $p'$, which latter, by Pauli's principle, must be a *vacant stationary state*.

(2) That the oscillatory state of the lattice shall

change to a new state, absorbing the energy and momentum differences $E-E'$, $p-p'$.

At high temperatures there is comparatively little difficulty in fulfilling these requirements, but at low temperatures Pauli's principle makes it difficult for an electron to do anything but gain energy, while the oscillations of the lattice, being almost entirely in their lowest state, find it almost impossible to lose energy. Thus the chance of exchanges (in spite of zero point energy), and therewith the resistance, rapidly diminishes.

Quantitative investigation on these lines has been carried through exactly for high temperatures and yields an electrical resistance varying as $T$, in admirable agreement with experiment. At low temperatures the investigation is much more difficult, and theoretical resistances varying like $T^3$, $T^4$, or $T^5$ have been obtained. While any of these is sometimes in fair agreement with experiment (see Fig. 6), it seems to me that the final investigation has yet to be made. We may, however, rest well content with what has been done until the next step can be taken in relating the theory to supra-conductivity. This step has not yet been taken. It may be connected with the theory of magnetic effects, about which there is much to be learnt from Kapitza's experiments. There is as yet no theory which accounts for his results, and, interesting as they are, we must perforce pass them by here.

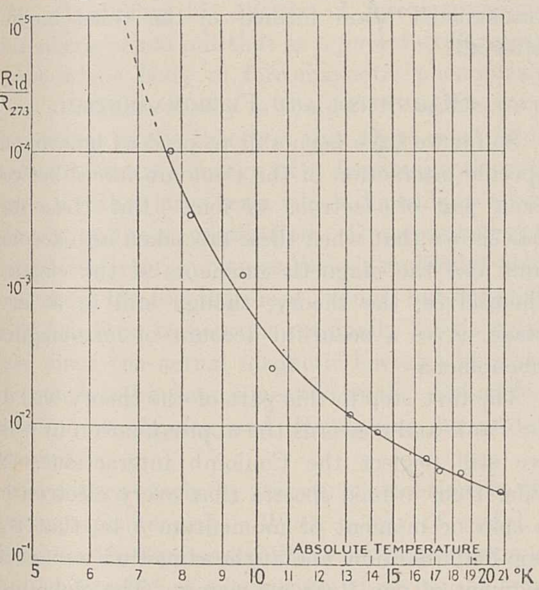


FIG. 6.—Change of the ideal resistance of lead near the absolute zero; plotted on a logarithmic scale. The resistance varies like $T^3$ in the region of 15°-20°, but is already varying faster than $T^5$ below 10°.

## Thermo-Electric Effects.

Before leaving the subject of conductivity, I should record that the theory as so far developed gives an explanation of reversible thermo-electric phenomena which in a general way is entirely satisfactory. The various thermodynamic relationships are of course preserved, and the Thomson and Peltier coefficients are given values of the right general order of magnitude and type of variation with absolute temperature, even by Sommerfeld's version. The refinements introduced by Bloch and Peierls could no doubt be made to give a very satisfactory account for many metals.

## Emission of Electrons.

We have so far tacitly assumed that all the electrons stay for ever in the metal, as of course they would have to do if the potential step at the surface were infinitely high. But if the step is finite, no part of what precedes is effectively altered, except that formula (2) indicates that there are present in the metal at any time a certain number of electrons (depending on the temperature) with sufficient energy to escape. Since free paths are rather long, it is sufficient to ignore the periodic lattice structure in the potential and consider what happens when an electron of kinetic energy $E$ falls on a potential step or hill, in which to a first approximation the potential is a function of the distance from the boundary alone. It is easy to show that in such a problem the motion of the electron parallel to the surface is unaffected, and the problem resolves itself into a one-dimensional one. We can now confine attention to a stream of electrons, of energy $W$ in their motion normal to the surface, incident from inside the metal on potential hills of various shapes. Typical natural and idealised boundary hills are shown in Fig. 7.

Now the classical solution of this problem is rather rigid and gives no scope for the observed variety. The electron would then always come out if $W>B$, the summit height of the hill, and never if $W<B$. In the quantum mechanics, however, things are very different. The electron never comes out if $W<C$, the *final* height of the step, but always has a non-zero chance of coming out if $W>C$, even though $W<B$. If we call this chance of emergence $D(W)$, and $N(W)dW$ the number of electrons incident on unit area in unit time with normal energies between $W$ and $W+dW$, the total saturated current $I$ per unit area which the metal can emit (supposing it is all collected as in the usual thermionic measurements) is given by

$$I=\epsilon\int_0^\infty N(W)D(W)dW.$$

Now on Sommerfeld's theory we know $N(W)$ (Fig. 8), and this theory is amply accurate for the present application. We can calculate $D(W)$ and hence the thermionic current $I$. I think one may say that these calculations are successful, for they show that

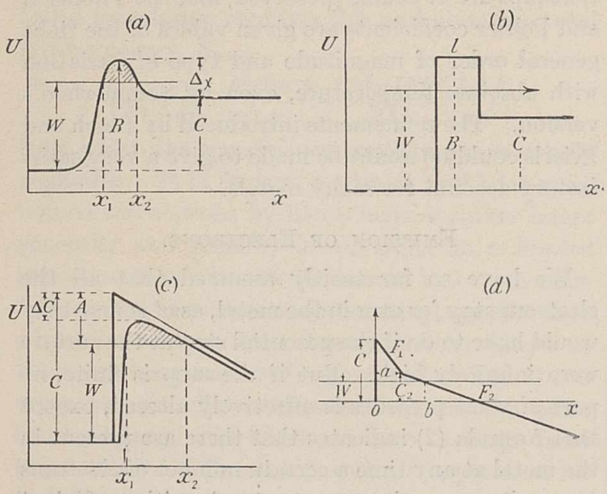


FIG. 7.—Typical natural and idealised boundary potential hills. (*a*) A natural type of hill when an electro-positive monomolecular layer is present and the image force is ignored; (*b*) the same idealised for simplicity of calculation, but without loss of any essential feature; (*c*) an idealised hill (a precipice) with a strong external field of force helping to pull out the electrons, and the same hill modified by the image effect (this modification explains the Schottky effect, and the unmodified hill the ordinary auto-electronic discharge); (*d*) a hill with two slopes, one intrinsic and the other that of the applied external field, explaining the combined effect of strong fields and monomolecular surface layers.

$D(W)$ is sensitive to the nature of the hill, that is, *to the nature of the surface layer, which may often be a layer of impurity present by accident or design.* The theoretical current is given by the formula

$$I = AT^2e^{-\chi/kT},$$

where $A$ and $\chi$ are constants characteristic of the emitter. This is of the well-known proper empirical

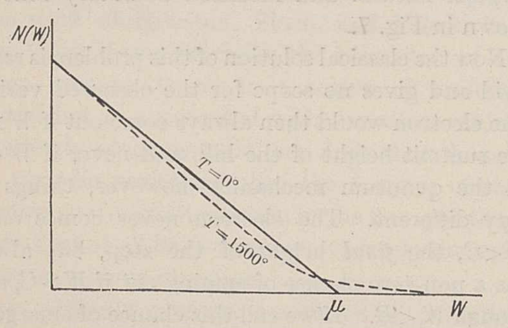


FIG. 8.—The number, $N(W)$, of electrons incident on the boundary with normal energy $W$ at temperatures of 0° and 1500° Kelvin.

form, but the theory further accounts correctly for the empirical correlation between $A$ and $\chi$ (the work-function), by means of the effect of these potential hills. I think it is fair to say that, using perfectly natural assumptions as to the nature of the boundary hill, the usual phenomena of emission of electrons, from hot metals, under very strong electric fields, and under the influence of light, can to a first approximation be accounted for to our complete satisfaction.

It is interesting to observe that an electron can go through a region in which its kinetic energy is apparently negative. Its chance of going through is large if the region is very thin, and dies away exponentially as the region widens. When we consider the wave nature of the electron, regarding it as a train of de Broglie waves, we see that this is closely analogous to a well-known phenomenon of physical optics. If light is incident on a plane interface at an angle greater than the critical angle, there is total internal reflection. But if the second medium is very thin and followed by a third medium the same as the first, there *is* a weak transmitted beam formed in the third medium after all.

### Magnetism and Ferromagnetism.

So far we have been able to proceed ignoring the specific interaction of the Coulomb forces between each pair of electrons or ions. But Heisenberg has shown that when these are taken into account, and also the magnetic moments of the electrons themselves, the theory, though still in a larval stage, gives a beautiful account of ferromagnetic phenomena.

The first step in this part of the theory was due to Pauli and concerns the approximation in which we still neglect the Coulomb interactions. We infer from atomic spectra that every electron has a spin or moment of momentum $h/4\pi$, that is, a one-half quantum, and at the same time a magnetic moment of one Bohr magneton. The Bohr magneton is the magnetic moment of any electronic orbit in any atom in which the electron has just one unit, $h/2\pi$, of orbital angular momentum. Thus the ratio of magnetic moment to angular momentum for the intrinsic spin of the electron must be just double the ratio of these quantities for any electronic central orbit. (Incidentally this fits beautifully into the later versions of relativistic quantum mechanics which we owe to Dirac.) Since, then, free metallic electrons carry each a Bohr magneton the axis of which can be turned along and against any imposed magnetic field, the alkalis and noble metals would be strongly paramagnetic with a temperature-dependence similar to that of the classical gas theory of Langevin, if it were not that once again Pauli's principle intervenes to prevent the accumulation of the electrons at any reasonable temperature into states in which an appreciable excess are orientated along the field.

The susceptibility of such an electron gas is not difficult to work out exactly. It turns out that there is theoretically a slight residual temperature-independent paramagnetic susceptibility of the same order as the usual diamagnetic one. In combination with a normal diamagnetic effect from the ions, this accounts very satisfactorily for such paramagnetic effects as are actually observed in the lighter alkalis. These effects are really extremely small, and from here on we shall ignore them and speak as if our idealised metals, neglecting specific interaction effects, were magnetically neutral. We have, of course, assumed here that the ions are inert, as they would be for the monovalent ions of the alkalis and the noble metals, which contain only completed groups of electrons.

In introducing his theory of ferromagnetism, Heisenberg points out that as a *formal* explanation of the whole body of ferromagnetic phenomena, Weiss's familiar theory is completely satisfactory. The essence of the theory is that there must be in the total internal energy of a ferromagnetic substance a rather large term which depends in a certain way on the magnetisation. Granted the existence of this term, known as Weiss's molecular field, everything fits together as it should, but the difficulty has been to account rationally for its existence, since the actual magnetic energies involved are some ten thousand times too small. This defect quantum mechanics and Heisenberg have now removed.

Heisenberg starts by directing attention to the *gyromagnetic anomaly*. When a bar of metal is magnetised it requires simultaneously a proportional angular moment of momentum which can be actually measured if the suspension is sufficiently delicate. Since all atomic orbits of electrons have one constant ratio, $e/(2mc)$, for magnetic moment to mechanical moment of momentum,* one expects to observe a constant ratio between the magnetisation and the angular momentum generated, from which $e/m$ may be calculated. The constant ratio is found, but for all ferromagnetics, for which alone until quite recently experiments have been made, the value of $e/m$ so observed has exactly twice its expected value. This is the so-called anomaly, but the observed value is exactly what one would expect if the magnetisation were contributed entirely by the orientation of the intrinsic spins of electrons and not of their orbits at all. We assume, therefore, that the magnetism of a ferromagnetic is derived entirely from the orientation of the spins of its loosely bound or free electrons. Heisenberg then finds that the terms needed to account for Weiss's field are to be found in the effect of the Coulomb forces—the electrostatic repulsions and attractions—which have hitherto been disregarded in our theory. In this step, however, we meet one of the most elegant subtleties of quantum mechanics which I will try to explain by using the simplest possible example.

In order to get a feasible method of approach to the interaction problem, Heisenberg idealises the metal in a different way from that which we have used hitherto. He imagines the crystal lattice to be composed of *atoms*, not ions, and expanded by continuous growth of the lattice constant until all the atoms are rather far apart. This looks so different a model as almost (if accepted) to deny the validity of our old one—but this inconsistency is only superficial, and it has, in fact, been shown by Bloch (at least, I think his argument is valid) that one can get similar effects to Heisenberg's by putting the interactions into our original model; the necessary technique is, however, more complicated and we may follow Heisenberg, recognising that there is nothing inconsistent with our previous model in his method of approximation, even if the magnetic and conduction electrons are the same, as recent experiments seem to suggest. We must therefore discusss the possible stationary states and energies of a large number of regularly arranged similar atomic systems each containing one, two, or a few electrons in similar orbits sufficiently loose for the interactions to matter. The large number, though essential to represent a metal, introduces merely complications of detail but none of kind; we can confine attention to *two*, and for purposes of illustration to two hydrogen atoms in their normal states.

Now here again the linearity of the wave equations comes in. It is impossible, when account is taken of the electrostatic interactions, for there to be a stationary state in which one electron is in one atom and the other in the other. If we could start with a particular assignment we should still find, after a time depending on the distance apart, that the electrons had changed places. When the atoms are fairly close together these exchanges become quite rapid and the corresponding energy term—the electrostatic interchange energy, as it is sometimes called—quite large and nearly comparable with the unperturbed energies. The system, of course, has actual stationary states (in fact, two) of definite energies, which may be regarded as built up by superposition in definite ways out of the unperturbed solutions with the electrons in their separate atoms.

* Here $c$ is the velocity of light and $e/m$ the ratio of charge to mass for the electron.

The two states have quite different energies which vary differently with the distance apart of the atoms (see Fig. 9). In one of them the electron spins and magnets balance each other out and the system has no magnetic moment. In the other the spins have to be parallel and the system has a magnetic moment of two Bohr magnetons. The energy difference of the two states, due to the electrostatic interchange term, is of altogether greater order, at least when the atoms are fairly close together, than the magnetic energy terms themselves. Now suppose we consider a number of such pairs set parallel and far apart from each other in a magnetic field. The magnetic field will alter the distribution of all the electron magnets (to what exact amount, of course, it is part of Heisenberg's problem to calculate), and therefore

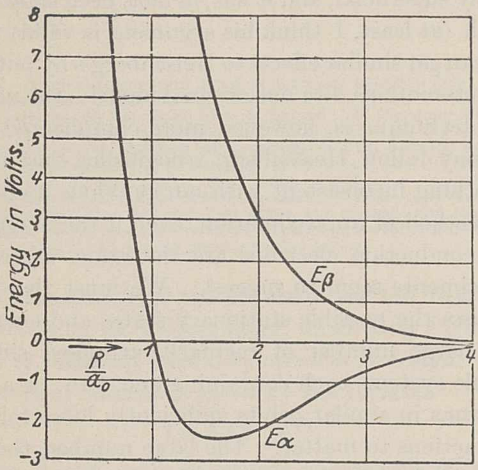


FIG. 9.—The potential energy of two colliding hydrogen atoms, showing the two quite distinct values which it can take.

the relative number of pairs which are neutralised or possess a magnetic moment, and of course the orientation of the latter. It will therefore have to alter the distribution of the pairs among their two stationary states, and therewith the energy content of the whole system, and that, too, by an amount depending on the magnetisation, which is very large compared with the magnetic energies themselves.

Here is the true origin of Weiss's molecular field! The atoms in a real metal lattice, each with an electron in a similar orbit, present a problem exactly similar in type, though it requires the help of abstract group theory conveniently to carry through the calculations. We can now safely proceed to the result of these calculations. Heisenberg finds, for a metal in which there is one 'active' electron per atom, that in the equilibrium state the magnetisation $\sigma$ is given by a root of equations which are essentially the same as Weiss's. Heisenberg neglects all interactions except those between nearest neighbours, and his final equations contain a quantity $J_0$ which is practically the interaction energy giving the energy separation between the stationary states of a pair of neighbours. In order that the metal may be capable of ferromagnetism, $J_0$ must be *positive*; in order that the Curie point may be at a reasonably high temperature, $J_0$ must be rather large. Heisenberg can show in a general way that these conditions are rather difficult of fulfilment and that ferromagnetics might be expected to be rare and to be found only (as they are) among the metals of least atomic volume—a genuine triumph! *

## CONCLUSION.

It must not be thought that I am too blindly optimistic about the present position of the theory of metals. There is much still to be done. I am optimistic to this extent—that I think that quantum mechanics, at our disposal to-day, is entirely adequate for a final electron theory of metals, or for any other physical theory which can treat the velocity of light as infinite. But metal theory is still far from adequate; I mean, of course, that part of the complete theory of metals is to deduce from the properties of atoms and the principles of quantum mechanics that a collection of, say, copper atoms with a reasonable energy content will form a metal and not, for example, a gas. The theory must next specify what simplifications may or may not be made in the further treatment of conduction.

In the work I have described these more fundamental problems have not been touched, but I think that a very promising beginning has been made on them by Slater. It appears likely that this work and the complete theory when it comes will very greatly modify the simple model which we have used hitherto. But part of my faith in quantum mechanics is derived from the fact that for any physically reasonable model it provides results which are always in good sensible accord with the requirements of experience. Theory and experiment may both be pushed ahead in the confident expectation that we are on the right lines and that progress will be sure and not particularly slow.

* Bloch (*Zeitschrift für Physik*, vol. 61, p. 206, 1930) has still further advanced the theory by improving it for low temperatures with the help of very important new methods developed by Slater (*Physical Review*, March, 1930).

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part in the development of airship transport, and that airship-meteorology must be developed along with airship-architecture and airship-mechanics. It was therefore only natural that when the Air Ministry despatched a mission to South Africa, Australia, New Zealand, and Ceylon to confer with the governments on airship routes and to survey possible sites, Giblett should be a member. On this journey, which lasted from May 5, 1927, to December 17, 1927, Giblett met the official meteorologists in the Dominions mentioned and also those in India and Egypt. Everywhere he made friends and impressed everyone with his scientific judgment and enthusiasm for his scientific work. He explained the problems and was highly successful in enlisting the co-operation of the various meteorological services in initiating the meteorological observations, both surface and upper air, on which alone a reliable survey of the atmosphere can be made.

During Giblett's absence the collection of data of upper winds and thunderstorm frequency in all parts of the world, which he had planned before leaving, had proceeded apace, and progress had been made in an investigation into the structure of the wind which will be a piece of classical work when the results are published.

The time had now arrived for making detailed plans for the journeys of the new airships *R100* and *R101*. At first it was proposed that both these airships should be employed on the India route, but early last year the plans were altered and it was decided that *R100* should go to Canada instead of to India. This necessitated a new and rapid meteorological survey of the Atlantic crossing which could only be made with the aid of synoptic charts. Much work was done, mainly by Giblett personally, to calculate the time taken to reach Canada on different routes under different weather conditions. In co-operation with the navigators he carried out on paper a number of crossings of the Atlantic. A date of departure would be chosen and then from the synoptic chart of the day a course would be laid down. The next day's chart showed where the airship would have been and then the course for the next day set. In this way the whole crossing was worked out in detail. A large number of occasions were studied and the statistics of the time taken on the different routes were discussed. An interesting result came out, namely, that the track across the north Atlantic, in spite of its greater winds and bad weather, was more frequently a better crossing than one farther south where the weather as a whole is much better. This was against the opinion generally held.

Simultaneously, in conjunction with the wireless staff, detailed plans for the collection of data by the airships when in flight were worked out, and areas delineated in which the ship would receive its forecasts from specified meteorological services, these being the meteorological services of London and Canada on the Canada route and those of London, Malta, Egypt, and India on the India route. A scheme for handing over responsibility from one service to the other was worked out in great detail.

Those of us who worked with Giblett were much impressed with the thoroughness with which he planned his organisation. It is impossible here to go into any further details of this work, but sufficient has probably been said to indicate the remarkable organising powers of Giblett. He was given almost complete freedom in working out his plans, and he never failed in the trust reposed in him.

There is not space to say much about his purely scientific work ; but Giblett was one of our very best meteorologists. He worked on turbulence, and applied the new work of Taylor and Richardson to the problem of evaporation from a large expanse of water. He was an enthusiastic follower of the Bergen school of forecasting and made use of the new knowledge of 'fronts' in all his forecasting for airships. The importance of atmospheric disturbances for the safety of airships led him to a detailed study of line squalls and water spouts, and his paper on line squalls, which he read before the Royal Aeronautical Society in 1927, contains the best review of our knowledge on this subject which exists.

Added to his ability as a man of science and as an organiser, Giblett possessed a charming personality. This was a great asset, for it endeared him to the technical officers with whom he worked, and he became a close personal friend to Colmore, Scott, and Richmond. It is heartbreaking to those of us who worked during the last five or six years with Giblett to see all his plans destroyed before they were put to the test, and the loss of so much knowledge and experience is a disaster compared with which the material loss is absolutely insignificant.

Giblett leaves a widow and daughter three years old, to whom, as well as to his mother, the sympathy of all will go out.

G. C. Simpson.

## Lieut.-Col. V. C. Richmond, O.B.E.

Vincent Crane Richmond, who was killed in the disaster to the *R101* on Sunday, Oct. 5, was the Assistant Director of Airship Development (Technical) at Cardington, and as such was responsible not only for the design work there but also for the control of airship research. He was born on Jan. 21, 1893. His education at the Royal College of Science, London, was that of a physicist rather than a mathematician, and it was indicative of his capacity that he was undertaking work that needed not only an understanding of those subjects but also considerable engineering knowledge as well.

Richmond's connexion with airships dates from 1915, when he was dealing with the manufacture of envelopes for non-rigids for the R.N.A.S. The design of the gas-bags and the methods of taking the stresses in the *R101* showed many signs of his experiences of those days. His experience of rigid airships was chiefly commenced in 1919, when he was attached to the Inter-Allied Commission in

Germany, in the department that dealt with the surrender of airships. It is probably no secret now, that as a result of his experience there he was convinced of the folly of the school of thought, then in the ascendency, that all the Zeppelin work then on hand should be destroyed and the organisation disbanded. Just how far his opposition to this policy influenced the official decision to reverse it, one outside those august circles is not permitted to know, but the many tributes that members of the Zeppelin Companies' staff have paid to him show that they have a full appreciation of his courage and far-sightedness upon this occasion.

One of Richmond's earliest problems at Cardington was that of carrying out full-scale experiments for the elucidation of many unsolved problems upon the co-ordination of wind-tunnel and full-scale test results. At this stage there were alarming discrepancies, and the existing information upon heavier-than-air craft was not of great use, as the conditions were so essentially different. The *R34*, upon which he carried out his experiments, then provided a fresh problem by breaking away from the mast and proceeding upon her now historic flight over the North Sea and back. The present-day British mooring system shows many signs of Richmond's ingenuity in dealing with the weaknesses made apparent by that mischance. It is no mere expression of opinion to say that it is completely successful. During last spring the *R101*, at the new mooring-mast, weathered one of the worst gales experienced in Great Britain for many years past.

Richmond's position as designer of the *R101* presented him with many problems that would have defeated men of less breadth of vision. He had to hold the balance between a set of conflicting requirements that must have been almost unparalleled in the history of scientific research. He had to hammer out an almost entirely new principle of construction that should overcome the weaknesses in previously accepted methods, as made apparent by the failure of the *R38* some years before. His materials were new and none too thoroughly investigated then. It was decided that every theory about which there was any possible doubt should be supported by a test upon a full-scale section of the structure. He had to satisfy a panel of independent experts who would have the eventual responsibility of certifying his ship as airworthy. Finally, he had to collaborate, as the necessity arose, with the designers of the sister ship, the *R100*.

During the last few years Richmond had been lecturing upon airship design at the Royal College of Science, South Kensington, and whatever the future of airships may be, the information disseminated through that source, and his students' personal remembrance of their teacher, will remain as, at least, one monument to his memory. "Operæ pretium est."

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We regret to announce the following deaths:

Dr. D. Adamson, past president of the Institution of Mechanical Engineers, on Oct. 11, aged sixty-one years.

Dr. H. R. H. Hall, Keeper of the Egyptian and Assyrian Antiquities, British Museum, on Oct. 13, aged fifty-seven years.

Prof. Paul Wagner, director of the Agricultural Research Station at Darmstadt from 1872 until 1923, on Aug. 26, aged eighty-seven years.

Dr. C. Powell White, for some years director of the Helen Swindells Cancer Research Laboratory at the University of Manchester, and pathologist at the Christie Hospital, Manchester, and a member of the executive of the British Empire Cancer Campaign, on Sept. 26, aged sixty-three years.

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## News and Views.

A feature of the developments of electron theory dealt with by Mr. R. H. Fowler in the Supplement which we publish in this issue of Nature is the extent to which older ideas have proved amenable to the requirements of quantum mechanics. The 'electron cloud', for example, has persisted, to provide, with certain modifications, the physical picture upon which most aspects of the theory are still developed, and the conception of a work-function for the passage of an electron through a surface has again emerged in the expressions for thermionic emission in a form little different, for practical purposes at least, from its original one. The amount of co-ordination and clarification of ideas effected by the quantum mechanics is nevertheless enormous, and it appears the more remarkable when the wide range of the electrical properties of metals to be explained is taken into account. Whilst there are still outstanding problems, notably in connexion with supra-conductivity and magnetic phenomena, as well, of course, as the fundamental ones referred to by Mr. Fowler at the end of his lecture, it will probably be generally admitted that his expectations are not unduly optimistic. Mr. Fowler has very modestly done less than justice to the importance of his personal contributions to the subject, which have been published in "Statistical Mechanics" and in numerous papers in the *Proceedings of the Royal Society* and the *Proceedings of the Cambridge Philosophical Society*.

As will be seen from Mr. Fowler's May lecture, the lines of experimental research which theory indicates as being probably most profitable at the present time would seem to be the electron emitting properties of surfaces, the properties of single crystals, galvano-magnetic phenomena generally, and supra-conductivity. Probably no stimulus would be required for the first two in any event. Both have practical applications of much importance, one in connexion with thermionic devices and photoelectric cells, and the other as the rational line of approach to a proper understanding of the elastic and electrical properties of the ordinary metals of engineering practice. The investigations of the magnetic properties of materials that are called for do not, however, appear likely to be capable of such applications, and the same is true to an even greater extent of the results to be obtained from low-temperature work. Magnetic and cryogenic laboratories are expensive to equip and maintain, and progress in these two directions may prove to be slower.

"This very year of grace", said Sir William Hardy, in his presidential address to the British Association of Refrigeration, "is not far from the three hundredth anniversary of the birth of modern science." Science is still in its raw youth; yet when we think of what it has already achieved, both as a philosophy and as a utility, the belief in an indefinite future of progress upwards for humanity scarcely surprises us. Sir William Hardy told his audience that he would leave the hillock which offered a view of the relation of science to industry in order to climb a hill whence the outlook on modern science was wider. Those who journeyed with him must have returned refreshed in spirit and eager to explore what lies beyond. Modern science is both a mode of thought and an austere discipline; it regards nothing as impossible, takes nothing for granted, and accepts nothing on authority. Modern science, which like other philosophies gives one of the many answers to the questions where man is and whither he is going, is not merely a docile slave which ministers to our comfort and our convenience; yet it cannot help contributing directly to the material well-being of mankind, for knowledge leads to mastery over the forces of Nature. Indeed, so great and so obvious is the material utility of science that its deeper significance has become obscured. The great utilities of science have been won not by aiming at them; they are the result of the organic growth of a vast body of interrelated knowledge. Natural science is a philosophic system which a man who would serve industry has to master as well as he can, and the more mastery he has the better services can he render.

Exceptions to the paradox of the utility of science, that the short cut to utility is to forget it, are apparent only, said Sir William Hardy; they exist when the needs of industry are ahead of scientific knowledge. Thus the search for new industrial metals is largely a matter of hit or miss, of trial and error. Astonishingly successful as the method has been, it would be dropped immediately if we knew enough about the solid state, for the development of fundamental laws results in an immense saving of time and labour. Assistance can be rendered to the fishing industry by improving the treatment of fish oils, but here again the shortest road to utility lies in the direction of an increase by experiment of the general body of fundamental knowledge. While it is true that material progress follows advance of thought and the development of fundamental considerations, we must not overlook the effect which such material progress itself has on our whole outlook. The first reaction to Copernicus's deposition of man from the important position which ancient belief and ancient science had given him was anger, and the second pessimism. He owes the re-establishment of confidence in himself and belief in his destiny to the tremendous triumphs of modern science both on the theoretical and on the practical sides. Yet the theory of progress needed a century to gain sufficient ascendancy to open the way for the tremendous optimism which seems so natural to us. Sir William Hardy also referred to the part which the State should take in fostering science on behalf of industry. Industry still regards science as a visitor to be warmly welcomed only in times of emergency. Mistrust of science will prevail so long as a polite education, in which a training in scientific method and outlook has no place, is accepted as complete. The collaboration of the State in scientific advancement is legitimate and necessary, but in the future a greater share of the burden must be shouldered by industry itself, for applied science cannot grow except in association with fundamental science.

The incoming president of the Royal Aeronautical Society, Mr. C. R. Fairey, delivered his presidential address on Oct. 9, taking as his subject "The Growth of Aviation". Comparing the feats of the pioneers with present-day achievements, Mr. Fairey remarked that whereas in 1903 the distance performance and its duration were 852 ft. and 59 sec. respectively, the corresponding figures for the present time are about 5000 miles and 67 hours. In 1903 flight was just above the ground and speed about 30 miles per hour; recently a height of 42,000 ft. was reached and the record for speed is 357 miles an hour. Progress has been continuous during the past twenty years, but it seems that, at any rate as regards speed and height, the limit for present methods will soon be reached. Military aviation has, in the past, provided the greatest support to the growth of the technical side. Commercial aviation has made remarkable strides and with present progress should soon be self-supporting. Australia had half the mileage of Great Britain in 1922, but in 1929 had equalled it; Canada had less than 200,000 miles in 1923, passed the total for Great Britain in 1928, and in 1929 nearly doubled it. The rate of expansion in both countries has been exceeded only by the United States. The total mileage of commercial aircraft in the United States in 1929 was 104,000,000 miles, an increase of 375 per cent of that for 1928 and equal to 80 per cent of the total flying mileage of the world. Subsidies for aviation last year throughout the world reached the total of £5,000,000, and the output of machines was not less than ten thousand. In the United States civil aviation is of more importance than the military side; in Great Britain 70 per cent of the manufacturing firms depend on Government contracts, but last year 15 per cent of the total products was exported. The future of aviation rests with the development of commercial flying.

Governments are slow to recognise the needs of scientific work, on the western side of the Atlantic as well as on the eastern, and the growth of the U.S. National Museum is a case in point. Started with appropriations from the funds left by an English man of science, James Smithson, the museum owed little to Congress until in 1877 it granted 250,000 dollars for a building. This, now the Arts and Industries Building, was supplemented in 1907 by the New National Museum Building, for which Congress voted 3,500,000 dollars. For long this building has ceased to be adequate housing for the enormous collections, and after much pleading Congress has passed, without a dissenting vote, the Smoot-Elliott Bill authorising an appropriation of 6,500,000 dollars for the enlargement of the U.S. National Museum. The new extension of the Natural History Building will roughly double the present floor space of nine and a half acres, and in addition to increased room for exhibits, this will permit enormous expansions of collections now hopelessly overcrowded. It is interesting to know, as showing an aspect of museum work which does not catch the public eye, and of which even scientific men are sometimes unnecessarily ignorant, that as against 1400 mammals on exhibition in the museum, 210,000 are included in the study collection—a proportion that suggests something of the hidden reserve of research and classification that lies behind the office doors.

With the co-operation of the authorities of various national museums, the Museums Association organised a short training course for curators during the week Oct. 6-11. The course was attended by 33 students from provincial museums, for the most part junior assistants, though a few seniors were glad to avail themselves of this opportunity. The gathering was welcomed in the new Conference Hall at the Science Museum by Sir Henry Lyons, when an opening address on first principles of museum work was given by Dr. F. A. Bather, and Dr. E. E. Lowe discussed some fundamental points in museum practice. Succeeding days were devoted to the Victoria and Albert Museum, with demonstrations on textiles, wood furniture, ceramics, prints, and the Circulation Department; the Natural History Museum, with demonstrations on habitat groups, casting of whales, preparing spirit specimens, and preparation of fossils for exhibition; the National Galleries in Trafalgar Square and at Millbank, with talks on storage, cataloguing, and the explanation of pictures; the laboratory of the British Museum, with a lecture on restoration of Egyptian relics.

Those who attended this course for museum curators expressed their high appreciation of the arrangements made and of the information imparted. There can be no doubt as to the success of the experiment, and the Museums Association will be encouraged to repeat it. The chief obstacle is the difficulty that members of the staff of provincial museums have in getting leave of absence and in paying the necessary expenses of travel and maintenance; hence the compression into five days of demonstrations that would, with more profit and less weariness, have occupied a fortnight or more. It is to be hoped that the authorities governing museums will see the benefit to themselves of helping the Association over this obstacle, and will not rely entirely on the generosity of individuals or on pecuniary assistance from outside.

The Council of the British Association has forwarded for the consideration of the Government a resolution urging that effect be given to the recommendations of the Royal Commission on National Museums and Galleries, for the establishment of a National Open-air Folk Museum. The view is expressed that such a museum would best fulfil its objects if established in or quite close to London, and it is further suggested that the possibility might be considered of utilising the gardens of the Royal Botanic Society in Regent's Park for this purpose, in view of their admirable situation and the proximity of a building (St. John's Lodge) suitable for exhibition purposes and offices; provided this can be done without interfering with the use of such part of the gardens as may be available for the scientific work of the Botanical Departments of the University of London.

The suggestion has recently been made that the swarming of bees is a social expedient due to the need for relief from overcrowding. In the September number of *Discovery* there is a remarkable account of the inducement of artificial swarms amongst termites, which indicates that amongst them climatic conditions may be the stimulus which sets the swarming instinct in motion. Under natural conditions, the swarming of termites takes place at the end of the equatorial summer, that is to say, at the beginning of the rainy season. The Bazinza people, natives of the south-western coast of the Victoria Nyanza, however, can induce swarming at almost any time, in June, July, August, or September, the last being even two months before the normal breaking of the rains. The process, described by R. A. J. Maguire and illustrated by photographs, is an elaborate one. A shelter of leaves is built over a termite mound so that the termitary is in subdued light, suggesting an overcast sky; sticks are beaten to suggest the patter of rain, and water is sprinkled over the 'nest'. Two hours of such activity bring the first winged termites from their galleries, and an hour later the artificial swarm, containing several thousands of 'fertiles', is over. The natives pound these, after the wings have been removed, into a paste which may be eaten raw, but is usually fried and eaten as a flavouring to grain or meat. The artificial swarm raises several biological problems: Is the colony for six months in a condition of overcrowding and awaiting the stimulus of season to break away, or is the stimulus of suitable conditions so strong that it compels swarming whether the termitary is overcrowded or not? Are winged forms specially associated with swarming, or do they exist in the termitary many months before normal swarming takes place? Finally, does the fact that normal swarming at the beginning of the rains may follow artificial swarming in the dry season, mean that between times fresh legions of winged fertiles have been produced to make up the lost numbers?

Marconi's Wireless Telegraph Co., Ltd., has built or received orders for many broadcasting stations in Europe; these include three stations in Switzerland, two in Poland, one in Finland, one in Rome and one in the Vatican City, and others at Trieste, Warsaw, and Brno. The Irish Free State has now placed an order with Marconi's for a sixty kilowatt broadcasting station. When completed it will be one of the most powerful stations in Europe. It will not begin to operate until the autumn of 1931. The waves will be controlled by an oscillating quartz crystal compensated for temperature. This will insure that the frequency of the transmitted waves will be kept constant within very narrow limits. The wave-length used will probably be 413 metres. It is interesting to note that power to operate the station will be supplied from the Shannon high-pressure network. Water-cooled and air-cooled valves will be used in the different amplifier stages. The aerial will be suspended from two lattice steel masts, each 330 ft. in height, and it is at a considerable distance from the transmitting building, in accordance with modern practice. Arrangements have been made to enable the aerial power to be doubled at a later date if required. The alternating current from the Shannon grid will be rectified at the station by a Brown Boveri arc rectifier.

DURING the last eighteen months, progress has been made in building the Battersea generating station. In about two years' time the two huge 80,000 kilowatt generators which have been ordered will begin working. Deptford West, another generating station of the London Power Company, will have a capacity of 195,000 kilowatts. A third large station will be the new Fulham station, the designs for which have been approved by the Central Electricity Board. As these stations will burn thousands of tons of coal daily, the gaseous products of combustion from which will be blown over central London, it is satisfactory to learn from a patent specification, No. 334,660, that Dr. S. L Pearce, the chief engineer of the London Power Co., and his assistants, are confident that the fumes problem has been overcome. Apparently there is little to fear from grit, dust, and noxious gases when the new stations begin to help the supply of electricity to London. It will not be long before the present stations are working at their maximum capacity, and there will soon be an urgent demand for more electric power. The method Dr. Pearce employs is to cause the products of combustion to pass through a conduit containing a series of spray washing departments. The direction of flow of the gases is altered several times, and they pass through curtains of liquid. The gases are subjected to the action of free iron or other suitable agents so as to convert the sulphur dioxide into sulphur trioxide. A method is also suggested of mixing the gases with ozonised air. Several other claims are made. By the use of hot water and catalysts, the sulphur dioxide, sulphurous acid, and sulphites can be readily converted into substances which can easily be removed.

IN a recent address entitled " Surgery in the Immediate Future ", delivered at Guy's Hospital Medical School, and published in the *British Medical Journal* of Oct. 11, Lord Moynihan repeated the assertion for which he had previously been criticised, to the effect that the craft of surgery has now almost reached its limit in respect both of range and of safety. While, however, surgery as a mere mechanical craft can scarcely advance any further, he maintained that it must still continue as a weapon of therapeutics and a weapon of research. He suggested that in the immediate future surgery will concern itself with the sympathetic and parasympathetic nerves in the chest, abdomen and pelvis, intrathoracic diseases, ductless glands, and questions of immunity. He deplored the absence of close affinity between laboratory workers, particularly physiologists, and clinicians, and attributed this defect to a lack of clear vision on the part of both. The new outlook in surgery demands a change in the training of the medical student, which should include a study of logic and philosophy, so as to render his mind more efficient and adaptable. In conclusion, Lord Moynihan criticised the Medical Research Council, which, he says, is too aloof from the day-to-day practitioner of medicine, and out of touch with the desires and needs of clinicians. He holds that the Council should either have a larger representation of clinical medicine and surgery or summon practitioners in an advising capacity.

SCIENCE Service, the well-known American science news agency, has supplied the American press for a considerable time with a regular series of simply written articles on meteorology entitled " Why the Weather ? " by Prof. C. F. Talman, the librarian of the United States Weather Bureau. A large number of these have appeared, and continue to appear at frequent intervals, normally as single sheets, each dealing with one particular item of meteorology. The date on which it is intended that the article shall appear is always indicated. This arrangement secures their appearance at a time when the matter under discussion is likely to be of particular interest to the general public. Prof. Talman is to be congratulated on the attractive way in which he writes, and on his unfailing supply of fresh material. With a meteorological library of the size of that of the U.S. Weather Bureau to draw upon, there is no reason why the supply should ever fail, and it is to be hoped that the standard of accuracy set in the early articles can be maintained in the future. In this respect one regrets to see, in a recent contribution entitled 'Buchan Spells', symptoms of a falling off. The impression given in this example is that Alexander Buchan—a sound meteorologist of extraordinary energy, to whom we owe a great debt—was guilty of publishing results of " no scientific value whatever ". The fact is that certain writers have attributed ideas to Buchan that the latter almost certainly never entertained, and have made an unjustified practical application of Buchan's results on 'recurrences' of weather to long-period weather forecasting.

THE continued improvement in the maps of the Ordnance Survey of Great Britain in recent years is a matter of general comment. In the Report of the Progress of the Ordnance Survey for 1929–30, the Director indicates some further changes that are proposed. The 1-inch map was originally an engraved map, and the engraved plate formed its basis until within the last few years, when for the 'popular' edition of the 1-inch map of Scotland drawings reproduced by the helio-zincographic process were used. Drawings are to be used also in the fourth revision of the 1-inch map of England and Wales which has recently been begun. The break with the engraved map will then be complete. Other changes include a more pleasing style of lettering, improved symbols for main roads and railways, the restoration of parish boundaries, and the indication of National Trust areas. The lettered and numbered two-inch reference squares will be abandoned in favour of a grid of 5000 yards side, so that positions can be easily defined by east and north co-ordinates. It is proposed also to incorporate the title, scale, and references as part of the border of the map, instead of leaving them in the blank margins.

The building of large steel frame buildings in cities is often accompanied with so much noise that it becomes very objectionable to dwellers in neighbouring houses. It seems to us that from this point of view alone the new electric welding methods that are coming into use should be welcomed. In the *Westinghouse International Magazine* for August a description is given of the new eleven-story building at East Pittsburgh, U.S.A., which will house the laboratories of the company. The whole of the structural steel framework has been joined up by arc welding without using a single rivet. As 1500 office workers are only a few feet away from the building, considerable annoyance has been avoided. The weight of the framework would have been increased three per cent if rivets had been used. The weather was very inclement when the foundation stone was laid. As this, however, was done in miniature in a reception room several hundred feet away from the actual corner stone which, through a mechanism controlled by photoelectric cells, followed exactly the motion of the model, the heavy rain did not matter. In one of the laboratories in the new building any kind of weather can be imitated so that devices can be tested under the most trying conditions. In another there will be a working model of an electric transmission system supplying a group of towns. There is also a laboratory where artificial lightning can be produced by simply turning a switch. This will be used for practical tests of lightning arresters. The flashes are photographed and analysed by the Norinder oscillograph.

Further developments in the equipment of eastern Canada with water-power are described in *Quebec* for July, in an article on the Beauharnois Canal project on the St. Lawrence river some twenty-five miles above Montreal. From Lake St. Francis on the river above Valleyfield, the new Beauharnois Canal is being cut to Lake St. Louis, a wide portion of the river lower down. The canal will be about fifteen miles long and will carry a quarter of the flow of the river. The fall of 83 feet is to be concentrated at the lower end and is planned to produce 500,000 horse-power, although less than half that amount will be available in two years' time. A 27-foot navigation channel in the canal will be part of the scheme for deep water access to the great lakes. The power will be readily utilised in southern Ontario and Quebec.

A public lecture entitled "Some Biological Aspects of Population" will be given at the London School of Economics and Political Science by Prof. Lancelot Hogben, research professor of social biology in the University of London, on Thursday, Oct. 23, at 5 p.m. The chair will be taken by Mr. H. G. Wells. Admission is free, without ticket. The recent foundation at London of a research chair in social biology is an event of importance to sociology generally, and Prof. Hogben's inaugural address should mark a stage in the study of human society.

Under the Order in Council dated Feb. 6, 1928, the Lord President of the Council has appointed Dr. E. J. Butler, Dr. Kenneth Lee, and Dr. N. V. Sidgwick to be members of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research. The following members of the Advisory Council have retired on completion of their terms of office: Prof. V. H. Blackman, Prof. F. G. Donnan, Prof. F. A. Lindemann. The appointment of Sir Ernest Rutherford to be chairman of the Advisory Council, as from Oct. 1, was announced in May last.

The second Henry Herbert Wills Memorial Lecture in physics, founded to commemorate the gift of the laboratory to the University of Bristol, will be given by Prof. J. Franck, of the University of Göttingen, on Saturday morning, Oct. 25, at 11.45, in the Henry Herbert Wills Physical Laboratory of the University of Bristol. The title of Prof. Franck's lecture will be "Relations between Spectroscopy and Chemistry". Visitors from other universities are cordially invited.

The twenty-first Annual Exhibition of Electrical, Optical, and other Physical Apparatus is to be held by the Physical Society and the Optical Society on Jan. 6–8, 1931, at the Imperial College of Science and Technology, South Kensington. As on previous occasions, there will be a Trade Section and a Research and Experimental Section, and the section for the work of apprentices and learners, introduced at the last Exhibition, is to be continued. The Research and Experimental Section will be arranged in three groups: (*a*) exhibits illustrating the results of recent physical research; (*b*) lecture experiments in physics; (*c*) historical exhibits in physics. No charge will be made for space or catalogue entries in the Research and Experimental Section. Offers of exhibits, giving particulars of space and other facilities required, should be communicated, not later than Oct. 30, to the Secretary, Exhibition Committee, 1 Lowther Gardens, Exhibition Road, London, S.W.7.

We much regret that throughout the review entitled "More Antarctic Meteorology" in Nature of Oct. 11, p. 561, the name of the author of the work noticed, Dr. Edward Kidson, was incorrectly spelled Kitson.

A catalogue (No. 14, October) of many second-hand books on botany has been received from Mr. J. H. Knowles, 92 Solon Road, S.W.2. It is one of the fullest recently sent to us.

Applications are invited for the following appointments, on or before the dates mentioned :—A handicraft master at the new Metal Work Room of the Bermondsey Central School, with qualifications in metal work—The Education Officer (E.2), County Hall, Westminster Bridge, S.E.1 (Oct. 20). A laboratory assistant at the County and City Mental Hospitals, Gloucester — The Medical Superintendent, County and City Mental Hospitals, Gloucester (Oct. 20). An assistant engineer inspector (mechanical) for service in England under the High Commissioner for India—The Director-General, India Store Department, Belvedere Road, S.E.1 (Oct. 24). Certifying officers under the Ministry of Transport for the various Area Traffic Commissioners' Offices in Great Britain—The Establishment Officer, Ministry of Transport, Whitehall Gardens, S.W.1 (Oct. 24). A whole-time member of the Medical Board for Silicosis—The Industrial Division, Home Office, Whitehall, S.W.1 (Oct. 25). An assistant director of public health (woman), for maternity and child welfare work in the Madras Presidency—The High Commissioner for India, General Department, India House, Aldwych, W.C.2 (Oct. 25). A junior engineer under the Safety in Mines Research Board, for research on colliery wire ropes—The Under-Secretary for Mines, Establishment Branch, Mines Department, Dean Stanley Street, S.W.1 (Oct. 27). A research assistant for physico-chemical work on cellulose at the Manchester College of Technology—The Principal, College of Technology, Manchester (Oct. 31). A research assistant in the University of Leeds for work in connexion with chemotherapy—The Registrar, University, Leeds (Oct. 31). A professor of pathology at the Medical College, Madras—The Secretary to the High Commissioner for India, General Department, India House, Aldwych, W.C.2 (Nov. 3). A technical officer (Grade 1) at the Royal Aircraft Establishment for mathematical work in the application of results of current research to the design of aircraft—The Chief Superintendent, R.A.E., South Farnborough, Hants (quoting A.389) (Nov. 5). An assistant lecturer in physics in the University of Sheffield—The Registrar, University, Sheffield (Nov. 8). A graduate master for biology at the Lord Wandsworth Agricultural College, Long Sutton, Basingstoke — The Principal, Lord Wandsworth Agricultural College, Long Sutton, Basingstoke. A junior botanist at the Rubber Research Institute of Malaya—The Secretary, London Advisory Committee, 2-4 Idol Lane, Eastcheap, E.C.3.

## Our Astronomical Column.

**Recent Sunspots.**—A large group of spots has recently passed across the sun's disc, with the centre of which it was almost coincident on Oct. 11·0. This group, visible for some days to the naked eye, is the largest that has appeared since last December. Its formation was that of a stream or 'bipolar' group, and there were appreciable changes from day to day in the appearance of the component spots. The activity of the group was also clearly evident by spectroscopic observations made at the Royal Observatory, Greenwich, especially between $9^h$ and $10^h$ G.M.T. on Oct. 6, when the observed radial movements of hydrogen gas, in the form of dark filaments near the leader spot, were of the order of 150 km./sec. A considerable tract of faculæ (visible in an ordinary telescope when the spots were near the sun's limb) and of bright hydrogen flocculi (seen at all times on the disc with the spectroheliscope or on spectroheliograms) accompanied the group, mainly in its rearward portion. Brilliant points or small patches of flocculi of a transient nature were also occasionally seen, in particular one that appeared with the formation of the dark filaments described above. The details of the position of the group are as follows :

| Date on Disc. | Central Meridian Passage. | Long. | Lat. | Max. Area. |
|---|---|---|---|---|
| Oct. 4-17 | Oct. 11·0 | 5° | $7\frac{1}{2}$° N. | 1300 millionths of sun's hemisphere. |

**Eros.**—The errors of the ephemeris of Eros that was published by Prof. G. Witt in vol. 85, No. 9, of *Mon. Not. Roy. Ast. Soc.* in 1925 for the present apparition are proving unexpectedly large. In *Astr. Nach.* No. 5729 he published an improved ephemeris for October 1930; but he now finds that his corrections in this were too small, and *Astr. Nach.* No. 5736 contains an ephemeris by him for November 1930 which has been further corrected with the aid of recent observations. The average correction of the original ephemeris (*Mon. Not. Roy. Ast. Soc.*, vol. 85) for November is $-40^{sec.}$ in R.A., and $+5'$ in declination. It is estimated that it will exceed a minute of time at the time of nearest approach next January. Since the list of comparison stars was drawn up on the basis of the old ephemeris, the error will cause some inconvenience for those who are taking photographs of large scale. Prof. Kobold suggests centring the plate on the old predicted position of the planet, so as to include the selected stars, but some of the observers express a preference for keeping the planet central on the plate, and sacrificing some of the comparison stars. The cause of the error in the ephemeris is not yet located, but as the predicted positions in 1928 were already some $3^{sec.}$ of R.A. in error, there is probably some undetected error in the computations, for an epoch not very long before 1928.

**Tempel's Second Periodic Comet.**—This comet was discovered in 1873 and was found to have the short period of 5 years and 2 months. It has now completed eleven revolutions since its discovery; it was observed in 1873, 1878, 1894, 1899, 1904, 1915, 1920, 1925, 1930. An ephemeris was published in the Handbook of the British Astronomical Association for 1930; with its aid Mr. H. E. Wood detected the comet photographically at the Union Observatory, Johannesburg, on Aug. 26; it was a faint, ill-defined object of the twelfth magnitude.

The following observations are to hand :

| Date. | R.A. 1930·0. | S. Decl. 1930·0. | Observer. |
|---|---|---|---|
| Aug. 26·73172 U.T. | $15^h\ 21^m\ 7{\cdot}20^s$ | 11° 58′ 35·6″ | H. E. Wood |
| „ 28·72106 „ | 15 25 56·28 | 12 41 16·2 | „ |
| Sept. 22·05471 „ | 16 35 53·6 | 20 57 15 | G. van Biesbroeck |

The last observation was made at Yerkes Observatory (*U.A.I. Circ.*, 298).

The following approximate orbit is given in the Handbook :

$$
\begin{array}{rl}
T & 1930 \text{ Oct. } 5{\cdot}5 \text{ U.T.} \\
\omega & 186^\circ\ 34'\ 32'' \\
\Omega & 120^\circ\ 52'\ 0'' \\
i & 12^\circ\ 46'\ 33''
\end{array}
\left.\vphantom{\begin{array}{l}a\\b\\c\\d\end{array}}\right\} 1930{\cdot}0
$$

$$
\begin{array}{rl}
\log q & 0{\cdot}1184 \\
e & 0{\cdot}5603 \\
\text{Period} & 5{\cdot}162 \text{ years}
\end{array}
$$

The comet is too far south for convenient observation in England.

## Research Items.

**Medieval Indian Culture.**—In the *Indian Antiquary* for September, Mr. K. de B. Codrington continues his study of the Ajanta frescoes, dealing with ships and boats, horse furniture, arms, metal-working, and pottery. The simplest form of boat is canoe-like and has two masts. It is clearly not a dug-out. Boats used for horse and elephant transport are broad in the beam and have grotesque *makara* figureheads. The large boat of Cave I has a high-pitched and finely cast bow and stern, on both of which *oculi* are painted. The passengers sit under an awning. A merchant ship has a full set of sails with two paddlers amidship. The arms show spears with short triangular blades and ferrules. Daggers are of one type with triangular blades and shaped grip. Three types of shields occur: a small parrying shield of metal; a round shield, usually of hide; and a curved oblong shield with tasselled edges which seems to have been made of black and white bamboo basket-work. Both composite and long bows are found. The swords are of three types: a type comparable with the modern *kukri* with the cutting edge on the incurved side; the long Indian sword with straight pointed blade; the leaf-bladed *pattisá*. All the Ajanta types have survived to-day and the straight and leaf-blade swords are found in Tinnevelly and Nilgiri iron age urn-burials. All have one type of hilt only—an angular V-shaped guard and disc-like pommel. The blade is usually strengthened by processes which run up it either in the middle or along the reverse, necessitated by the peculiar properties of Indian steel, which lacks flexibility. Little can be said of the metal work. Beside lamps and gadrooned pots in Cave I, the only articles recognisable are the mirrors. These are circular with a knob behind, pierced to take a ring or cord. This form is specially associated with China. Mirrors are rare in archæological finds in India, only three being recorded.

**Stone Ages in South-east India.**—The contents of *Antiquity* for September include a communication by M. C. Burkitt and L. A. Cammiade on palæolithic implements from sites in south-east India situated in the wild country in the Eastern Ghats, which run parallel to the coast for some three hundred miles. The climatic succession which has been worked out for this area may be correlated with the climatic changes now being worked out in East Africa. Four cultures are distinguished, each with its characteristic series of industries. Series 1 is distinguished by the presence of hand-axes made of quartzite which can be closely paralleled by finds from Africa. Thus hand-axes from the Bhaavanasi gravels and from Chodavaram are compared with the gigantic specimen from Nigeria now at Cambridge and examples from Victoria West in South Africa. Series 2 are flake industries with some much more neatly made hand-axes, the material used being chiefly quartzite. Series 3 is characterised by the occurrence of slender blades with blunted backs, a few burins, planing tools, and end-scrapers. This series is best found at sites at the east and west ends of the Nandi-Kanama Pass. Small crescents perhaps link Series 3 with Series 4, a rather monotonous series of microliths with some larger tools. A large number of this series are found on the surface near the Godaveri. They link up with the Wilton of South Africa. The comparative poverty of industries of Series 3 would suggest that we are here on the periphery of the distribution of the Upper Palæolithic found in South, North, and East Africa and extending as far as Transjordania; while Series 4 forms part of the great spread of mesolithic culture.

**Education of Cats.**—A Chinese psychologist, Zing Yang Kuo, of the University of Chekiang (according to Science Service, of Washington, D.C.), has been testing the reactions of cats to rats and mice. Kittens were isolated at an early age and never knew rats, others were given rats and mice for companions almost from birth, still others were allowed to see their mothers catch and kill rats. Some kittens were brought up as vegetarians, others on a diet of meat and fish. Of the 21 normally educated kittens which watched their parents rat-hunting, 85 per cent killed a rat before reaching the age of four months. Of the 20 kittens kept in a ratless environment, only 45 per cent killed rats without being taught; and of the kittens raised with rats, not one ever killed any of its playmates or any rat of its kind, but 3 of these 18 kittens killed other kinds of rats. The vegetarian kittens were as keen as the others to kill rats, but most of them would not eat the rats they had killed. Indeed, after three to four months of a meatless diet, the vegetarians refused any meat. The experiments indicate that the explanation that a cat hunts by 'instinct' is inadequate, and that the reaction of cat to rat is much more complex and variable than has been supposed. "Our study shows that kittens can be made to kill a rat, to love it, to hate it, to fear it, or to play with it."

**Distribution of Birds in the open Atlantic Ocean.**—During Prof. Johs. Schmidt's *Dana* Expeditions of 1920–22 in the north Atlantic and Gulf of Panama, primarily in pursuit of the breeding area of the fresh-water eel, ornithological observations were made by an experienced worker, P. Jespersen (*Oceanographical Results of the Danish Dana Expeditions, 1920–22*, No. 7, 1930. Copenhagen: Geydendalske Boghandel; London: Wheldon and Wesley, Ltd., 1930, 6*s*.). The frequency of the birds observed was greater nearer land, and here fulmars, kittiwakes, skuas, and shear-waters predominated, but birds were seen on the entire stretch across the ocean, the open sea being mainly populated by kittiwakes, skuas, shearwaters, and, particularly in the summer half-year, storm-petrels. Contrary to expectation, the number of birds over the Sargasso Sea was less than elsewhere in the open water, and this scarcity (the German plankton expedition of 1889 saw only one bird in seventeen days) was found to be correlated with a relative scarcity of plankton. The distribution of plankton throughout the whole Atlantic, most abundant near the coasts, least abundant in the Sargasso Sea, appears to determine the presence or otherwise of the sea birds. Thus the Sargasso Sea had fewest birds, but the Gulf Stream area, with its considerably larger quantity of plankton, had a greatly increased number of birds—at least ten times as many per day as in the central part of the Sargasso Sea. In the north-eastern corner of the Atlantic, between Great Britain and Iceland and around the Faroes, the largest quantities of plankton were found, and there was a correspondingly rich bird population.

**Manganese in Insects.**—Qualitative determinations of manganese in the ash of insects made in the Biogeochemical Laboratory of the Russian Academy of Sciences by A. P. Vinogradov and M. V. Neustrueva (*Comptes rendus, Acad. Sci.*, No. 6, 1930) proved that it is present in all species (30) examined. The quantity varies from $2 \times 10^{-4}$ to $1{\cdot}2 \times 10^{-2}$ per cent, the Lepidoptera containing less manganese than any other insects. In the species feeding on green parts of plants, the quantity of manganese is usually higher, but on the other hand it is very high in some insects with different food—for example, in the mole-cricket (*Gryllotalpa gryllotalpa*, L.) and red ants (*Formica rufa*, L.). In the ants, manganese was found to be concentrated mainly in the abdomen, and it may be suggested that this fact has some relation to the physiology of their poison glands, in connexion with the fermentative oxidation processes taking place there and leading to the production of formic acid. In other insects, there is more manganese in the more active species; this may again depend on more active gaseous metabolism. The influence of manganese on fermentative process in other organisms is well known and its rôle in insects may possibly be the same.

**A Lethal Gene in Cattle.**—The usual method of breeding cattle, in which bulls are mated to their daughters, tends to bring out recessive genes. No less than eight, and possibly ten, recessive lethal genes have now been found in cattle, compared with eleven in all other mammals. One of these, called short spine, has been described by Mohr and Wriedt (*Jour. Genetics*, vol. 22, No. 2), who discuss the best method for testing the genetical condition of bulls to be used for breeding. The new lethal appeared in the Oplandske mountain cattle of Norway. The anatomical condition of the homozygous lethal is described. The vertebral column and sternum are greatly shortened, as are the neck and thorax; the vertebræ are reduced in number through fusion, and the ribs number six or seven instead of thirteen. The head and legs are normal. These calves die at birth. This condition is exactly complementary to the sub-lethal type called amputated, in which the skeleton of the head and legs is chiefly affected. Both show the same type of inheritance. They must have arisen in the germplasm as mutations. Eleven of the short-spine type have occurred among the descendants of a particular bull. It is not known from elsewhere and may have originated in this bull or his immediate ancestors. As it has not spread far, there should be a good chance of preventing its further spread in the germplasm of other herds, and it may be possible to eliminate it altogether by careful breeding.

**Origin of Maize.**—The origin of maize, which was widely cultivated by the Indians in North and South America at the time of the discovery of these lands, has long been a subject of hypothesis and investigation. The botanical evidence points to Mexico or Central America as the original home of the plant, but it has never been found wild and must have been greatly altered during the long period of Indian cultivation. It has been generally assumed that the wild plant, whatever its form, was extinct, perhaps even in Aztec times. Mrs. Zelia Nuttall (*Jour. of Heredity*, vol. 21, No. 5) now cites documentary evidence which may lead to a different view. The Chevalier Boturini, an Italian traveller and naturalist, published a work in 1746, after spending eight years in Mexico collecting evidence of its former civilisation. He describes the native tradition concerning the origin of agriculture, that while setting fire to the forests to clear them of wild beasts they noticed grains of maize which had been roasted, and finding them delicious, collected fresh seeds to plant in the soil. Boturini asserts that he himself found in New Spain a maize growing wild in the forests, with a small ear and few seeds, but more delicate in flavour than the cultivated kind. This may have been the wild progenitor of maize, since become extinct through deforestation and other causes. That the plant may still survive in Guatemala is suggested by the experience of Mr. Oliver La Farge, an American, who recently found there, at an attitude of 5000-6000 feet, a wild plant used by the natives in May, when the maize fields had only just been sown. This plant had ears about two inches long, "looking rather like oat-sheaves without the 'whiskers', and having the unmistakable flavour of corn".

**Root System of the Tree.**—Some results of a very intensive study of the root system of the apple and allied fruit trees are presented by V. A. Kolesnikov in the *Journal of Pomology and Horticultural Science*, vol. 8, No. 3, 1930. The root systems of seedlings and young trees were washed free from soil, studied, and measured. As the result of such laborious work, the author is able to present an interesting picture of the gradual growth of the root system. During the season, branch roots emerge, and then again upon these, branches of a lower order, until, in apples and pears, in a growing season of five or six months, roots of eight orders had appeared. Perhaps as a result, the average length reached by a root is not long and appears to tend to a standard length in a variety. Also, the roots tend to die back from the tip, the branches first formed, which lie nearer the base of any root, dying back first; and therefore the root system, around the base of the trunk, tends to become free of young branches with an absorbing surface still active, whilst further from the trunk a dense array of branching roots, those of younger orders still actively absorbent, are advancing farther into the soil, with a habit of growth which will cause them to 'quarter the ground' thoroughly as they advance.

**Dutch Elm Disease in America.**—Science Service, of Washington, D.C., reports that the Dutch elm disease, caused by a fungus known as *Graphium ulmi*, which has caused serious damage to elm trees in Holland and has spread into other European countries, has been discovered in Ohio. Three trees in Cleveland and one in Cincinnati have been definitely identified as harbouring the disease and destroyed. A number of other suspected trees in the State are under observation, and State and Federal pathologists are on the look out for new infections. The Dutch elm disease was first observed in Holland soon after the War. Its symptoms are sudden wilting, followed by yellowing and dropping of the leaves. Death of the tree follows, either at once or after a few years of struggle. No cure is known.

**Nature of Lake Eyre.**—Although Lake Eyre covers about four thousand square miles, little was known of its nature or surface conditions until Mr. C. T. Madigan investigated it, first by air and later by motor-car and on foot, last year. Some of his results are given in a paper in the *Geographical Journal* for September. There is no permanent water and the whole bed is dry at times. Two-thirds of the surface is covered by a salt crust from one inch to seventeen inches in thickness. This crust is 95 per cent common salt with some gypsum and small amounts of calcium, magnesium, and potassium chlorides. Underneath there is a damp gypseous clay to a depth of about eighteen feet, below which is a bed of dolomite. The salt has no seasonal banding, which shows that muddy waters do not flow into the basin. There is no probability that the crust is periodically dissolved. Mr. Madigan notes that the most generous calculation could admit a flooding of only 56 inches a year, against an evaporation of 100 inches. The conclusion, apart from the absence of banding in the salt, is that river floods scarcely affect the lake. Local rain would only affect the first third of an inch of the salt, which is soiled with blown debris. Mr. Madigan favours the theory that the salts date from Upper Tertiary to recent times and are cyclic in origin.

**Band Spectra of Tin Monoxide.**—In a communication received from Mr. P. C. Mahanti, University College of Science and Technology, Calcutta, it is announced that a number of bands occurring in the spectrum of the tin arc in air, most of them already recorded by Eder and Valenta in the oxy-coal gas flame, have been allocated to three distinct systems. The constants for these have the following approximate values in cm.$^{-1}$:

| | $\nu_e$ | $\omega_e'$ | $\omega_e''$ |
|---|---|---|---|
| System *A* | 29,631 | 589 | 830 |
| ,, *B* | 23,018 | 800 | 1045 |
| ,, *C* | 22,676 | 589 | 800 |

Further particulars will shortly be published elsewhere.

**Forbidden Lines of Neutral Oxygen.**—In a short note in the first August number of the *Physical Review*, Dr. I. S. Bowen points out that two weak lines at 6302 A. and 6364 A., which occur in the spectra of certain nebulæ, are almost certainly forbidden lines of the oxygen arc spectrum (O I). An analysis of the ultra-violet arc spectrum of this element has been given by Dr. R. Frerichs in the same issue of this journal, fixing for the first time the value of the low metastable terms from which the auroral green line (5577 A.) arises, and from this it follows that new 'forbidden' lines should occur at $6299 \pm 5$A. and $6363 \pm 5$A. It is also mentioned that Prof. Paschen has succeeded in obtaining these lines in the laboratory, and has fixed their wave-lengths accurately at 6300·00 A. and 6363·86 A., so that the assignation of the nebular lines is reasonable. The auroral green line itself has now also been produced from a discharge tube with almost the same isolation as in the spectrum of the night sky, a source having been described by Prof. McLennan and Mr. Ireton in the September number of the *Proceedings of the Royal Society*, which yields only this and $\lambda$6965 of argon.

**Raman Spectra.**—The July issue of the *Indian Journal of Physics* contains a group of eight papers on the Raman effect, which add considerably to our knowledge of infra-red vibrations. The substances which have been investigated include both a number of elements (chlorine, sulphur, carbon, and phosphorus) and some fifty organic and inorganic compounds, chosen mainly in groups which permit of the assignation of more or less definite frequencies to definite radicles. An investigation of the polarisation of Raman lines is described, which shows that there is a close similarity between the polarisation characters of the spectra of compounds of similar structure, and so indicates that polarisation is controlled by the geometry of the oscillations. The utility of the Raman effect in the investigations of physico-chemical properties is also well illustrated by one paper on the influence of polymerisation and molecular association on Raman spectra, with special reference to sulphur trioxide, and by a second on the determination of the characteristic frequency of the diamond by this method; whilst there are numerous good reproductions of the actual spectra from which the measurements have been made.

**Anti-fogging Agents in Developers.**—Since nearly seventy years ago, many and very various substances have been proposed and added to either the emulsion or the developer to prevent fogging, that is, the deposition of metallic silver during development where the plate has received no exposure to light, and probably a decreasing increase of deposit in other parts. It has been generally supposed that these agents slowed development and so gave time for the denser deposits to increase in opacity before the 'fog' began to show. But P. Wulff patented in Germany several organic bodies for eliminating fog when added to emulsions and claimed that they do not affect the densities of the image. This claim is new, so A. P. H. Trivelli and E. C. Jensen, of the Kodak Research Laboratories (*Jour. Franklin Institute*, p. 287, Sept. 1930), investigated the anti-fogging action of 6-nitro-benziminazole when added to the developer using hydroquinone, pyrogallol, and *p*-aminophenol as developers. They give a large number of curves and tables to show their actual results, and conclude that 6-nitro-benziminazole with these developers is superior to potassium bromide and potassium iodide, giving the least depression of image densities with the same fog-removing quality. With the *p*-aminophenol developer, there was no change of image densities up to 12 minutes development at 20° C. The work is being continued.

**Oxidations by Iodic Acid.**—Iodic acid has not been much used in organic chemistry, and exclusively in acid solutions. In the September number of the *Journal of the American Chemical Society*, Evans and Dehn show that it can be applied in acid, neutral, and alkaline solutions, and appears to be very selective in its action. The use of iodic acid was shown to lead to improvement in various preparations. A 92 per cent yield of purpurogallin was obtained with sodium iodate and pyrogallol, and benzoin is directly convertible into benzilic acid by the action of sodium iodate in concentrated sodium hydroxide.

**Dielectric Polarisations of Normal Paraffins.**—In the September number of the *Journal of the American Chemical Society*, Dornte and Smyth describe measurements of the polarisations of normal paraffins from pentane to dodecane over ranges of temperature. The polarisations calculated from the dielectric constants and densities increase about 1 per cent per 100° rise in temperature. The polarisation appears to be an additive property, as would be expected. The values of the electric moments of the molecules are regarded as approximately zero, and the conclusion is drawn that the bonds of alkyl radicals possess no polarity detectable through electric moments arising from them.

**Turbulence in Internal Combustion Engines.**—The effect of turbulence upon the charge of an internal combustion engine is of great importance, since a stagnant mixture could not be burned in the time available for its combustion in the engine cylinder. In a paper read before Section G (Engineering) of the British Association at Bristol, which appeared in full in *Engineering* for Sept. 5, Messrs. T. F. Hurley and R. Cook attempt to elucidate some points associated with this phenomena; in their efforts to control the condition of turbulence within the engine cylinder they have obtained some interesting data. The paper is in two parts, the first of which deals with experiments when an engine is motored round. In these tests the condition of port entry is varied by means of shaped vanes and the movement of the particles of the incoming charge deduced from photographs of the path of sparks, etc., travelling with the air flow. The second part of the paper presents the results of actual running tests upon the same engine and with the same modifications of inlet port flow, the authors noting the effect upon highest useful compression ratio (H.U.C.R.) of the different conditions of turbulence so set up. It must be borne in mind, however, that the data given refer to only one shape of combustion head, and therefore it would not be wise to generalise from these results. Also, it seems a little difficult and misleading to determine the value of the H.U.C.R. so expressed, when knocking actually occurs at a compression ratio well below the figures given, namely, 5·15 to 1.

## Conduction of the Heart-beat.

THE mode of propagation of the wave of contraction in the wall of the heart was thought, up to fifty years ago, to take place along nerve trunks. Gaskell was the first (1882) to show definitely that not only does the heart-beat arise spontaneously in muscle cells but also that the conduction of the excitation from one part of the heart wall to another takes place by muscular tissue. No difficulty was encountered in demonstrating that muscular continuity existed in the case of the lower vertebrates such as the frog and the tortoise. It was generally believed, however, that no such muscular continuity existed between the auricles and ventricles of the mammal; thus, in the human heart, auricle and ventricle on each side were supposed to be united solely by a fibrous ring.

It was not until the year 1892 that Prof. Stanley Kent observed certain muscular bands running from auricle to ventricle which he described in the following terms: "Between the auricle and ventricle and lying in the connective tissue ring are modified muscle cells, usually spindle-shaped, nucleated, granular, becoming extremely narrow in parts and then swelling out again, transversely striated" (*Proc. Jour. Physiol.*, 6, Nov. 12, 1892). In the following year Kent in Great Britain and His in Germany established the existence of a definite bundle of specialised muscle joining auricle to ventricle. This *A-V* bundle (bundle of His) was further worked out by Tawara (1906), who showed that it had its origin in the *A-V* node of similarly specialised tissue situated at the base of the auricular septum on the right side below and to the right of the coronary sinus. He traced the *A-V* bundle along the top of the interventricular septum just below its membranous part where it divides into the right and left septal divisions; these pass down in each ventricle on the interventricular septum into the papillary muscle arising from the septum. Each half of the bundle gives off several branches which break up more and more, finally forming a reticulated sheet of tissue over the greater part of the ventricles just under the endocardium.

The fibres composing the tissue are distinguished by their primitive character. They are more granular in appearance, due to a higher glycogen content, and consequently appear less striated. The *A-V* bundle forms the only continuous muscular tissue between auricles and ventricles and destruction of it causes complete abolition of the normal sequence of beat between auricles and ventricles. It is now universally accepted that the transmission of excitation in the mammalian heart takes place by means of this muscular bundle.

In 1913 Kent described in the *Journal of Physiology* (*Proc.*) another band of muscular tissue near the auriculo-ventricular groove on the *right* lateral aspect of the heart. In 1914 he demonstrated that this right lateral auriculo-ventricular junction exists in the human heart and establishes connexion between the auricular muscle (right auricle) and the ventricular muscle of the right lateral wall of the heart (right ventricle).

This observation of Kent has either been overlooked or not accepted by other investigators. The division of the well-established auriculo-ventricular bundle (bundle of His) into two to supply both ventricles has adequately accounted for the phenomena observed up to the present in disease and laboratory experiments. Also search by other observers for other conducting paths by the method of combined dissection and serial sectioning has not met with any success; Kent attributes this to the difficulty and tediousness of the task.

In a meeting of Section I (Physiology) of the British Association at Bristol on Sept. 4 last, Prof. Kent brought forward new evidence for the existence of his 'right lateral connexion'. He now backs up the earlier morphological demonstration with experiments on the beating heart proving that the right lateral bundle is a functional entity. If all structures between the auricles and ventricles are severed, leaving only a bridge of tissue between right auricle and ventricle on the *postero-lateral* position, co-ordination persists.

Further, he has found it possible by successive cuts to diminish gradually the breadth of this bridge until it is no more than *one millimetre* across and still co-ordination persists. This co-ordination is of such a kind that the normally occurring contractions of the auricle are followed regularly by contractions of the ventricles, and when spontaneous beats have ceased, artificially excited contractions of the ventricle pass through to the auricle and are followed by auricular beats. Prof. Kent comes to the conclusion that a conducting path exists in this postero-lateral region, which in the absence of the main *A-V* bundle may function in such a way as to maintain the co-ordination of the chambers of the heart.

## Meteorology in Agriculture.

AT a time like the present, more than usual interest attaches to any attempts to derive economic advantage from applied science. At the annual paper-reading conference held at the Meteorological Office on Sept. 25 and 26 last under the auspices of the Ministry of Agriculture and Fisheries, all the papers had direct or indirect applications in this direction. The subject of agricultural meteorology is one of those which, through its hybrid nature, is apt to be regarded as the business of neither the meteorologist nor the agriculturist, and it was a recognition of this fact that led to the inauguration a few years ago of the crop-weather scheme and of these annual conferences, where the two classes of investigator can meet and pool the knowledge gained in their special subjects.

Of the five papers read on the first day, the first, by Mr. E. V. Newnham, was mainly meteorological in interest but had an agricultural application in that the subject under discussion—nocturnal radiation from the earth's surface—is one of importance for its bearing upon the damage done to crops by night frosts. A brief summary was given of observations made in this field since Dr. Wells wrote his classical "Essay on Dew", more than a hundred years ago. A qualitative discussion of various factors controlling the temperatures of objects freely exposed to the clear sky at night was followed by a consideration of the desirability of replacing the present form of terrestrial radiation thermometer by an instrument capable of giving quantitative measurements of the heat lost to space in the course of a whole night. Emphasis was laid on the need for further information about the relative powers of common substances for emitting the long-wave radiations appropriate to bodies at low temperatures.

Mr. I. J. Schapringer followed with a paper on the effect of weather on sugar beet. Tracing the effects of weather upon the various stages of cultivation of this crop, it was shown that the equable climate of England gives us a distinct advantage over Continental countries, where the harvesting of the beet has generally to be completed by the end of October, owing to the probability that frost and snow will intervene if matters are delayed longer. Where this does not happen, harvesting can be spread over a longer period, extending up to Christmas, and the sugar factory can be employed at a moderate pressure of work over a correspondingly lengthened period. The dampness of the climate of England is no obstacle; the fact that our output per acre is about 25 per cent less than on the Continent is explainable largely by the fact that English farmers have not yet discovered the varieties of beet best suited for the climate—a handicap resulting from the seventy extra years of experience in the industry possessed by their rivals abroad.

Mr. J. Hammond showed interesting diagrams illustrating the variation in the proportional size of different parts of Herefordshire cattle at different ages, in the course of a paper on the effects of climatic conditions on animal production. He showed also how variations of weather affect the chemical composition of plants and, through this agency, the character of the growth made by animals feeding on these plants.

The effect of weather on soils was shown by Dr. Ogg to be greater than had at one time been supposed. Owing mainly to the work of certain Russian investigators, modern soil classification is being made on new and much more satisfactory lines than in the past, the principal difference being that formerly the importance of the geological character of the parent rock, the breaking up and transformation of which is responsible for a particular soil, was over-estimated. Wet climates tend to give acid soils and dry climates alkali ones, temperature coming in as a modifying factor. Without any other data than a knowledge of mean temperature and rainfall and of the character of the humus-supplying vegetation, the distribution of the principal types of soil can be roughly mapped out in any country, and work on these lines is being carried out internationally.

In the course of an account of work at Rothamsted Experimental Station on the relationship between the weather of different months and the effectiveness of various artificial manures, Sir John Russell showed the necessity for employing modern mathematical statistical analysis in order to separate the influence of different weather factors. Once this has been done, the result often leaves for solution a comparatively simple relationship that can be explained by chemical experiment in the laboratory. Stress was laid upon the economic importance of a scientific variation of the chemical proportions of artificial manures in accordance with the predominant weather factors for the crop in question, and on the extent to which the application of such a principle can make the yield independent of the meteorological character of the season.

The second day of the conference was occupied mainly with a consideration of the influence of weather upon insect pests. The general impression gained from these papers was that the subject is a harder one to investigate than that of simple plant growth. This arises partly from the fact that many of the pests are of very small size, and the meteorological data available normally do not define exactly the conditions which the pest experiences. There is the added difficulty that the parasites that exercise so large a control over the severity of the attack of a pest are not normally affected in a similar way to their hosts by abnormal weather. Mr. A. Roebuck, who spoke on this subject, showed that where the host and parasite are oppositely affected, great fluctuations of severity of a pest are to be expected; and that, on the other hand, similarity of reaction to weather tends towards limited variation, and therefore to an absence of epidemics. Dr. W. M. Davies described how humidity affects Collembola (springtail): types with a very primitive breathing system are absolutely dependent upon high humidity, whereas those possessing a more advanced tracheal system can withstand relatively dry conditions.

The conference closed with a very interesting account by R. T. Parkhurst of the way in which fowls can be induced to lay as many eggs in the autumn and winter as during the remainder of the year by artificially increasing the hours of light during the dark days, the result being a satisfactory yield at the time when prices are highest. The method is being applied successfully in the United States, especially where cheap electricity is available.

## Migration in Butterflies and Moths.*

It is well known that locusts migrate, but few realise that similar movements take place in other insects, and particularly in the dragonflies and the butterflies and moths. The evidence for such movements is chiefly of two kinds. First, it is found that some insects exist over large areas only for a short time, and after a period of absence may appear again suddenly in large numbers. Secondly, observers, particularly but by no means entirely in the tropics, have often seen hundreds of thousands of butterflies moving steadily in one direction, sometimes passing for hours on end and sometimes even for days or weeks.

By collecting such evidence it has been possible to get an idea of the regular movement made by some species. Thus the Monarch or Milkweed butterfly of North America is found during the summer throughout the greater part of the continent, even reaching so far north as Hudson Bay. In the autumn all the individuals in the north collect together in great bands and fly a thousand or so miles south to the Gulf States or Southern California, where they spend the winter clinging in masses to trees. In the spring the bands break up and the butterflies fly north, laying eggs as they go, to repopulate the whole area—some completing another thousand or fifteen hundred miles flight on the return journey.

In West Africa, Europe, and western Asia, the greatest migrant is the Painted Lady butterfly, which in the spring crosses the Sahara and Egyptian deserts from some almost unknown sources to the south; crosses the Mediterranean, often in hundreds of thousands; flies more or less northward through Europe, usually reaching the shores of Great Britain in early June, and sometimes individual stragglers are seen in the extreme north of Iceland or within a few degrees of the Arctic Circle. The total distance covered by these flights may be between two and three thousand miles, but at present it is not possible to say with certainty if any one individual flies the whole distance or if it is covered by two successive generations. The butterflies lay eggs as they go and in England a local-bred generation may result in August or September, but there is practically no evidence of the survival of this butterfly in north and central Europe from one year to the next. Another remark-

* Substance of a paper read by Mr. C. B. Williams before Section D (Zoology) of the British Association at Bristol on Sept. 8.

able fact is that there is at present little or no evidence of any return movement towards the south in the autumn.

The common Large Cabbage White butterfly is also a migrant, particularly in central Europe, where about July large swarms seem to originate either in Scandinavia or on islands in the Baltic, and fly southward through Germany in clouds like snowstorms. Some of these flights deviate to the west and may cross the North Sea and appear on the eastern shores of Great Britain.

Similar flights occur in all parts of the world; West Africa, East Africa, South Africa, India, Ceylon, Central and South America, and Australia, all have their migrant butterflies. The sight of hundreds of thousands of butterflies passing a point steadily in a fixed direction day after day is one never to be forgotten. Mr. Williams stated that in East Africa he has seen a 'skipper' butterfly flying to the south on every fine day for more than six weeks, in numbers which reached a maximum of more than five hundred per minute on a 22 yards front. On another occasion at the same station there were simultaneous flights of two different species of butterflies going on in exactly opposite directions for nearly a month, each species keeping strictly to its predetermined path. Further, on one day while these two flights were going on, there was a third flight of millions of locusts moving diagonally across the other flights and not in any way interfering with them.

Nothing is yet known of the reasons for these movements or of the factors which determine the direction of flight. It can, however, be stated quite definitely that the insects are *not* blown by the wind. Examination of a large number of records show that the flights are as often directly against the wind as with it, and may cross it any angle.

Butterflies in migration appear to have an urge to fly continuously in one fixed direction; they appear to be conscious of that direction and make every effort to keep to it in spite of the disturbance due to wind and the presence of obstacles in their path. They usually avoid small obstacles by flying over them, or more rarely round them, but have been seen beating themselves against the wall of a house or entering open windows. Efforts to keep to the desired path have often been observed, and they have been recorded as flying through railway tunnels or in at one side and out at the other of partly constructed buildings, rather than depart from it.

Similar movements occur in many species of moths, but information about them is much more difficult to obtain, owing to the fact that the majority of these migrations take place at night.

## Fishing Methods of the Maori.*

THERE appears hitherto to have been little information placed on record concerning Maori fishing methods and devices. Mr. Elsdon Best's monograph, in which every aspect of Maori fishing activity is clearly and fully described, is therefore a welcome addition to the scanty literature which already exists.

Fishing operations in all the countries of the world have connected with them many strange beliefs, weird superstitions, and quaint ceremonies to celebrate special occasions such as the launching of a new boat or the first dip of a new net. Fishing in Maoriland was no exception to the rule, and many strange and interesting rites and usages connected with the craft are described. Many of these have their counterpart in other lands; a few seem to be peculiar to the Maori.

Sea fishing was considered by the Maori to be essentially a task for men. The boats, however, were almost invariably met by the women, to whom the entire subsequent care of the catch was left. Women also were expected to collect shellfish and allowed to take part in the capture of small fresh-water fish, but eel-fishing was confined entirely to men.

The most useful and interesting part of the bulletin is the section dealing with fishing implements, their manufacture and use. Where the conditions were suitable, nets of various kinds were mainly used, chief among them being a kind of giant seine which might be anything up to 1000 yards in length. The making of such a net, the material of which was unscraped flax, was the work of all the inhabitants of a village and was made use of to benefit all the part proprietors of it. These nets were five to six feet in depth, provided with sinkers along the bottom and floats of very light wood (instead of the usual cork) along the top. A point of unusual interest about these seines and the other nets of the Maori is that so far back as can be traced, the knots used for making the meshes were exactly the same as those of our own European nets. How this knot came to be discovered and adopted in net-making by peoples and tribes all over the world amongst whom intercommunication must have been impossible is a riddle yet to be explained.

In addition to the great seines, many smaller nets were employed, including drag nets and set nets, but no mention is made of drift nets. These do not appear to have been used in Maoriland. Line fishing also was largely practised, especially along rocky coastlines where drag-nets could not be employed. Wood, bone, stone, and shells were all used by the Maori in the manufacture of fish hooks. When Europeans arrived in the country, however, the natives soon learned the advantages of metal for the making of such implements.

The bulletin is attractively produced and well illustrated, but appears to suffer slightly from the fact that the author, apart from his researches in producing this work, seems previously to have had little intimate contact with fishermen and fisheries.

* Fishing Methods and Devices of the Maori. By Elsdon Best. Dominion Museum Bulletin No. 12. 1929. Dominion Museum, Wellington, New Zealand. Also obtainable from New Zealand Government Offices, 415 Strand, London, W.C.2. Price: Paper Cover, 9*s*.; Cloth Cover, 11*s*. 6*d*.

## Recent Work on Buttercups.

AT the present time considerable attention is being paid to these familiar wild flowers, comprising the genus *Ranunculus*, the largest one in that attractive family the Ranunculaceæ. Parkin has in recent years (*Annals of Botany* 42; 1928) emphasised the fact that in this genus two distinct types of petal occur—one yellow and *glossy*, typical of the common buttercups of our fields and meadows; and the other white (occasionally yellow or even red), with a *mat* surface, exemplified only in Great Britain by the water buttercups (Batrachium section). The former type of petal is probably unique among flowers, possessing peculiar structural features, one of which is the large amount of starch contained in it and restricted to the part that is glossy. It is suggested that this large genus might be conveniently and perhaps also phylogenetically divided into two sub-genera—one containing the glossy and the other the mat petalled species.

Marsden-Jones and Turrill are collaborating in a genetical study of this genus, and last year they published a preliminary account of their results with the two common buttercups, *Ranunculus acris* and *R. bulbosus* (*Jour. of Genetics*, **21**, abstract in Nature, **124**, p. 928). One of the most interesting points connected with these species is the occurrence of plants functionally only female. Reference to these was made in the correspondence columns of Nature last year (**123**, pp. 568, 798, and 911).

A Japanese botanist, M. Kumazawa, has this year published the results of his morphological and anatomical study of the species of *Ranunculus* occurring in his own country (*Jour. Faculty of Science*, Univ. Tokyo, Botany 2, pt. 3). The island empire of Japan is sometimes regarded as the eastern counterpart of the British kingdom, and in keeping with this it so happens that the number of species (sixteen) found there is about equal to the number usually recognised in Britain. Furthermore, as in the British flora, the only species that have not yellow and glossy petals are white water buttercups.

Two endemic species present interesting vegetative features. *Ranunculus Zuccarini* has root tubers suggestive of those of the Lesser Celandine (*R. Ficaria*). *Ranunculus flagellifolius* has filiform leaves monocotyledonous in appearance. Evidence is brought forward to show that these foliar organs have evolved through the transformation of the whole of an ordinary leaf and are not merely modified leaf stalks (phyllodes).

The main part of the paper is taken up with vascular anatomy. Interesting points in connexion with the endodermis are described. There is a marked tendency in the stem to closed bundles of the monocotyledonous type.

From the morphological and anatomical point of view *Ranunculus sceleratus*, a widely distributed species and fairly common in Britain, is regarded probably as one of the most primitive members of the genus.

## Autumn-sown Cereals.

THE choice of a good variety of cereal may make a difference of more than twenty per cent in a farmer's returns, and yet the crop will cost him no more to grow. For this reason the National Institute of Agricultural Botany, Cambridge, has issued a number of recommendations, based on careful trials at a number of stations, as to varieties of cereals suitable for autumn sowing. These do not necessarily apply to the north of England, but may be accepted with confidence in other districts.

The reaction of different varieties of wheat to diseases such as foot-rot or whiteheads is as yet far from complete, but there is no reason to believe that any one variety is markedly more resistant or susceptible to them than another. As regards winter hardiness, it should be borne in mind that other factors besides frost resistance are important in England, and that on the whole, Scandinavian and Dutch wheats are less adapted to our conditions than such a variety as *Squarehead's Master*. The value of change of seed is still a vexed question, but there seems no evidence (given equal purity and germination) that foreign-grown seed is preferable to stocks of the same variety grown in England.

*Wilhelmina* or *Victor* are the most trustworthy high-yielding varieties on soils in good condition; *Yeoman* or *Yeoman II* possess unique bread-making quality and are the varieties to grow on the richest soils or under intensive manuring; *Little Joss* should be chosen for the lighter wheat soils, particularly in Norfolk, or where fertility is low; *Iron III*, though less trustworthy than *Wilhelmina* and apt to develop rust, like *Weibull's Standard*, finds a place on heavy soils. *Rivett*, or *Blue Cone*, probably outyields all other varieties on heavy soils in the south of England, and *Squarehead's Master* stands by itself in its adaptability to all sorts of conditions and the regularity with which it gives a certain crop.

*Grey Winter* is the only really trustworthy variety of oats, but its weak straw is a serious disadvantage. If strength of straw is an essential point, black-grained *Bountiful* is suggested. There is no winter-hardy white oat on the market. As regards barley, the ordinary six-row winter variety gives a satisfactory crop, but the grain is not of malting quality. However, although none of the malting barleys are winter-hardy, *Plumage Archer* and *Spratt Archer* can usually be grown successfully, if exposed situations and badly drained soil are avoided, and when autumn-sown, out-yield similar spring-sown crops. Anyone wishing for fuller particulars is advised to write to the National Institute of Agricultural Botany at Cambridge.

## University and Educational Intelligence.

Birmingham.—The celebration of the jubilee of Mason College and the thirtieth anniversary of the granting of a charter to the University commenced on Oct. 13. The Chancellor, the Viscount Cecil of Chelwood, in the course of his address, referred to the foundation in 1880, by Sir Josiah Mason, of Mason College as a college of science and technical knowledge for Birmingham, at a cost of £200,000. The College became the University in 1900, and the first principal was Sir Oliver Lodge, who was present at the celebrations. The honorary degree of doctor of laws was conferred on the following, among others: Sir Henry Hadow, Sir William Hardy, Sir Thomas Lewis, and Dr. F. E. Smith.

Cambridge.—At Trinity College, J. W. Brunyate, L. H. Gray, and R. E. A. C. Paley have been elected to fellowships. At Corpus Christi College, Dr. G. S. Carter, formerly lecturer in zoology in the University of Glasgow, has been elected to a fellowship.

The John Winbolt Prize has been awarded to S. Steele, of Christ's College, for a dissertation on "Chemical Changes in Fuel-air Mixtures in an Internal Combustion Engine during Compression".

London.—Two courses of advanced lectures have been arranged in the Faculty of Engineering at King's College. Mr. T. G. Rose is giving three lectures on "Management", on Tuesdays, beginning Oct. 21; and Col. C. H. Bressey, Chief Engineer, Roads Department, Ministry of Transport, will deliver three lectures on "Modern Road Construction", on Tuesdays, beginning Nov. 11. Particulars can be obtained from the College.

Manchester.—The Council has accepted with regret the resignation of Prof. O. T. Jones, who has held the chair of geology and the directorship of the Geological Laboratories since 1919. Prof. Jones has been elected to the Woodwardian chair of geology in the University of Cambridge, and will vacate his Manchester appointment in December. The Council has also accepted the resignations of Dr. John Walton, senior lecturer in botany, who has been elected to the Regius chair of botany in the University of Glasgow, and of Mr. L. J. F. Brimble, lecturer in botany.

Dr. J. H. Frazer (Johns Hopkins) has been appointed lecturer in mathematical physics.

ST. ANDREWS.—At the graduation ceremonial on Oct. 10, the honorary degree of LL.D. was conferred upon J. A. C. Kynoch, emeritus professor of midwifery, University College, Dundee.

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APPLICATIONS are invited by the Zoological Society of London for an aquarium research fellowship for three years, of the annual value of £350. The successful applicant will be expected to do research in connexion with aquatic life, principally in the laboratory attached to the Society's aquarium, under the general advice of some naturalist appointed by the committee, and to report quarterly to the committee on the progress of the research. Applications should be addressed to Sir Peter Chalmers Mitchell, Zoological Society, Regent's Park, N.W.8, and received on or before Nov. 3.

AN arrangement has existed for the past six years whereby, when a candidate for a Higher National Certificate in Mechanical Engineering at the termination of an advanced course includes a specialised automobile engineering subject in his final examination, the signature of the president of the Institution of Automobile Engineers can be added to any certificate awarded. This arrangement has now been extended to ordinary certificates awarded at the termination of senior part-time courses. Applications should be addressed in the first instance to the Board of Education.

THE following research fellowships are open to members of the British Federation of University Women :—A Senior International Fellowship (offered by the International Federation of University Women), value £250 ; an American International Fellowship (offered by the American Association of University Women), value approximately £300 ; a Caroline Spurgeon International Scholarship in Arts (offered by the Directors of the Crosby Hall Association), value £100 a year for two years ; an International Residential Scholarship at Crosby Hall (offered by the British Federation of University Women), value £100; and a German International Fellowship (offered by the German Federation of University Women), value approximately £100. Application forms and regulations are obtainable from the Secretary, British Federation of University Women, Crosby Hall, Cheyne Walk, S.W.3.

FOR the tenth year in succession, Trinity College, Cambridge, announces the offer of a Research Studentship open to graduates of other universities who propose to go to Cambridge in October next as candidates for the degree of Ph.D. The value of the Studentship may be as much as £300 a year if the pecuniary circumstances of the successful candidate require so large a sum. Applications must reach the Senior Tutor not later than July 1, 1931. The same College offers, as usual, Dominion and Colonial Exhibitions to students of Dominion and Colonial universities. These Exhibitions are of the titular value of £40, but their actual value is such sum (if any) not exceeding the titular value as the College Council may from time to time hold to be justified by the exhibitioner's financial circumstances, and the Council has power, if it sees fit and if funds are available, to award an additional payment. Candidates must apply through the principal authority of their university, and applications should reach the Senior Tutor (from whom further particulars may be obtained) by July 1, 1931.

## Historic Natural Events.

**Oct. 19, 1800. Hailstorm in Bedfordshire.**—During a violent thunderstorm in Bedfordshire, hailstones fell, shaped like oblate spheroids, six to nine inches in circumference.

**Oct. 19, 1917. Unexpected Upper Winds.**—A fleet of thirteen Zeppelin airships attacked London on Oct. 19 in weather conditions which appeared settled. Owing to the unexpected development of a barometric depression, however, a very strong cold north-east wind sprang up at some height above the ground. Fog and cloud prevented the raiders from determining their position, and they were carried southward over France, where they were discovered. The motors being handicapped by the intense cold, the greater part of the Zeppelin fleet was destroyed.

**Oct. 20, 1743. Hurricane at Port Royal.**—A furious hurricane began at 6 P.M. at Port Royal, Jamaica. Many houses were blown down, but most of the damage was done by the sea, which rose many feet and destroyed all the wharves, while the streets were several feet under water. Out of 105 ships in the harbour only one rode out the storm, and a great number of marines were drowned. The hurricane was followed by a pestilence which caused still greater loss of life.

**Oct. 22–25, 1805. Trafalgar Gales.**—After the battle of Trafalgar violent south-westerly gales blew on the south-west coast of Spain, and it proved impossible to get the majority of the captured French and Spanish ships into Gibraltar.

**Oct. 23–24, 1924. Typhoon off Coast of Annam.**—A typhoon of exceptional violence, accompanied by torrential rains and a storm wave, travelled along the coast of Annam, causing floods, loss of harvests, and great damage to buildings, roads, bridges, railways, and telegraph lines. The regions which suffered most were the provinces of Kinhoa and Song Ba.

**Oct. 24, 1847. Aurora Borealis.**—A brilliant display was observed from London on the night of Oct. 24–25. As described by J. Glaisher, it began with a bright red streamer in the north-west at 6.30 P.M., but was not well developed until 9.55 P.M., when a pyramid of red and orange light appeared in the north-west, 5° in diameter at the base, and resembling the glow from an immense conflagration. At 10 P.M. this had become deep crimson, and a similar one had formed to the east-north-east, these two pyramids forming the boundaries of a fan-shaped mass of vibrating silvery columns converging to a point a few degrees south of the zenith. About 10.20 P.M. the moon, which had been shining from a cloudless sky, was suddenly surrounded for a few minutes by a fine corona, with concentric circles of grey, violet, green, and red. Soon after 11.15 a bright arch appeared extending from north-west to south-east, with flickering streamers both above it and below it. This continued until 1 A.M. There were magnetic disturbances at Greenwich on Oct. 22 and 24.

**Oct. 25, 1665. Gale in London.**—There was a violent gale in London with much rain. It is stated in the *Philosophical Transactions* that during this storm the barometer stood at 28½ in., and that on the evening of Oct. 26 it descended nearly to 27½ in.

**Oct. 25, 1859. *Royal Charter* Storm.**—During a terrible storm the *Royal Charter* was wrecked on the coast of Anglesea, with the loss of nearly five hundred lives. This disaster led directly to the establishment of a meteorological service in England and to the issue of gale warnings by Admiral FitzRoy. In the same storm the *Great Eastern* narrowly escaped destruction at Holyhead, while Stephenson's viaduct at Penmaenmawr was carried away, the old Chain Pier at Brighton was destroyed, and great damage was done to the railway on the beach below the cliffs at Dover.

## Societies and Academies.

### Paris.

**Academy of Sciences**, Sept. 8.—**W. Vernadsky**: The radium in aquatic organisms. The amounts of radium in different species of *Lemna* growing in lakes containing known amounts of radium have been determined. The concentration of radium in the living plant is 100-650 times that present in the water. The amounts of radium vary considerably with the species of *Lemna*, and this variation does not depend on the weight of the individual plant. The question as to what is the function of radium in the vital processes of *Lemna* still remains unanswered.—**Auguste Lumière** and **Mme. R. H. Grange**: The protective action of cholesterol against shock caused by flocculates. The facts cited prove that injections of cholesterol protect the animal (rabbit) against shocks of the anaphylactic type.—**Joergen Rybner**: Nomograms for transformations between rectangular and polar co-ordinates and for complex hyperbolic functions.—**Cl. Chevalley**: The theory of normic residues.—**Radu Badesco**: Logarithmic solutions of an integral equation.—**Luca Teodoriu**: A partial differential equation which occurs in the problem of average.—**F. Charles** and **J. Flandrin**: Contribution to the study of Cretaceous soils in the north of Anatolia (Asia Minor).—**P. Fallot, A. Marin**, and **M. Blumenthal**: The limestone chain of the Spanish Rif between Xauen and oued M'ter.—**Th. Biéler-Chatelan**: The polysynthetic quaternary glacier of Monti Simbruini (Central Apennines). The causes of its extension. The author concludes that in the Apennines, in spite of the altitudes being lower than the Alps, the quaternary glaciers could have reached dimensions comparable with those of Alpine glaciers, this being due to the heavy rainfall which has always characterised these ranges.—**Jules Amar**: The diaphragm origin of respiration.—**Angelo Migliavacca**: The lipochrome interstitial cells of the uterus.—**Rémy Collin** and **Pierre Florentin**: The growth of the nuclei in geometrical progression in Lœwenthal's gland.—**Mme. Y. Khouvine, E. Aubel**, and **L. Chevillard**: The mechanism of the transformation of pyruvic acid into lactic acid in the liver.

### Geneva.

**Society of Physics and Natural History**, July 3.—**H. Decker**: System of organic combinations. The author has constructed curves permitting the prediction of the possible combinations; carbon and hydrogen are plotted on rectangular co-ordinates. For the more complex combinations, he combines several networks with a parallelogram mesh, such that all possible combinations find their place at the nodes of a parallelopiped mesh.—**R. Cherbuliez** and **G. de Mandrot**: The disaggregation of casein in acetamide. By heating casein in acetamide a true depolymerisation of the casein can be brought about without the chemical intervention of a foreign substance. This depolymerisation is accompanied by a profound modification of the original molecular edifice, but does not destroy the groupings which give on hydrolysis the amino-acids characteristic of the original proteid.—**A. Georg**: The determination of the constitution of the disaccharides by the method of methylation and its application to Fischer's isomaltose. By this method, the author deduces two possible constitutions for isomaltose; either that of a 6-α-glucoside (1·5)-glucose (1·5) or that of a 5-glucoside (1·5)-glucose (1·5). The first appears to be the more probable.—**Eugene Pittard** and **Juan Comas**: The condylo-diaphysary angle (angle of divergence) of the femurs of Bushmen, Hottentots, and Griquas. The authors find differences between the averages for the two sexes and others between the right and left sides. These differences are not the same in the Hottentots and the Griquas; granted a common origin, these differences may perhaps be attributed to the mode of life.

### Leningrad.

**Academy of Sciences** (*Comptes rendus*, No. 1, 1930).—**F. Loewinson-Lessing**: A contribution to the petrography of Kamtchatka. Analyses of a series of specimens of lavas from Kamtchatka are given; most of the lavas are characterised by the presence of basic plagioclase phenocrysts, of basaltic hornblende, and by vitrophyric texture; lavas containing pyroxene are rare.—**I. Vinogradov**: The least primary root.—**I. Medvedev**: The problem of bios. The question as to whether yeast cells can develop in an artificial medium, without living elements in it, has been decided by various authors differently. This difference is due to neglecting the possible osmosis of physiologically active substances (bios) from the yeast cells themselves into the medium. Removing the substances so diffused by quick washing proved that they play a very important part in the development of yeast in an artificial medium.—**N. Dneprovsky**: The fundamental systems of the declination of stars.

*Comptes rendus* (No. 2, 1930).—**A. Tchitchibabin**: (1) Non-tanning substances in the extract from the rhizome of *Saxifraga* (*Bergenia*) *crassifolia*. (2) Arbutine. Both the rhizome and the leaves of *S. crassifolia* contain up to 10 per cent of the dry weight of the glucoside arbutine, which has so far been known only in the plants of the family Ericaceæ and in *Pyrola*.—(2) Non-tanning substances of *Statice*: (1) Myricetine. A species of *Statice* from Turkestan was found to contain up to 1 per cent of the glucoside myricetine.—**A. Tchitchibabin** and **N. A. Preobrazhenskii**: The synthesis of the pylopic acids and the structure of the pylocarpine.—**N. N. Jakovlev**: (1) The genus *Petschoracrinus* and the transition from the dicyclic crinoids to the monocyclic ones. A series of specimens of *Petschoracrinus* exhibited a complete transition from the monocyclic to the dicyclic type, and the use of this character for the separation of the two sub-classes appears not to be justified.—(2) The primary pores of *Cystoblastus*. The madreporite of *C. kokeni* is kidney-shaped, perforated, and placed over the three interradial plates. On the concave side of the madreporite there is an orifice which must represent the gonopore.—**E. Perepelkin**: (1) The alteration of the rotation of the sun with the height. Prominences in different layers of the sun's atmosphere rotate with the same velocity.—(2) The separation of velocities of different gases in the prominences.—**J. Medvedev**: The theory of the simultaneous action of the external factors on the yield of crops. A method is offered for the calculation of the optimum combination of factors.

### Rome.

**Royal National Academy of the Lincei**, May 4.—**E. Paternò**: The origins of stereochemistry. So long ago as 1869, Paternò proved the existence of two isomeric compounds of the formula $C_2HCl_5$ and attempted to explain their isomerism by means of spacial structural formulæ.—**F. Zambonini** and **Silvia Restaino**: Double sulphates of rare earth and alkali metals (13). Sulphates of praseodymium and ammonium. In addition to the compound, $Pr_2(SO_4)_3$, $(NH_4)_2SO_4$, $8H_2O$, described by von Scheele in 1898, these sulphates form the anhydrous double compound, $Pr_2(SO_4)_3$, $5(NH_4)_2SO_4$, which is stable at 25° in contact with solutions containing from 63 to 56 per cent of ammonium sulphate and from 0·2 to 0·6 per cent of the praseodymium salt. The crystallographic characters of this double salt are described.—**S. Franchi**: The non-existence of the 'nappe de l'Embrunais' in Italian territory, indicated to the south of Mont Blanc in a geological map by Léon Moret.—**F. Zambonini and A. Ferrari**: The identity in crystalline structure of the cancrinite of Monte Somma with that of Mias. The recent and most satisfactory analyses of cancrinite indicate the formula, $3(Na_2, Ca)Al_2Si_2O_8(Na_2, Ca)CO_3$, with a slight excess of carbonates and a variable proportion of water.—**Giulio Bemporad**: The significance of the principle of the arithmetic mean.—**R. Caccioppoli**: A general theorem on the existence of unit elements in a functional transformation.—**M. Brelot**: The integrals of $(1)\Delta u = c(M)u(M)$ $(c \geq o)$ in the neighbourhood of a singular point 0 of $c(M)$.—**Enrico Volterra**: The deformation of an elastic medium due to a small displacement of an immersed rigid sphere.—**B. Caldonazzo**: Plane irrotational motions of perfect liquids in the presence of a movable disc.—**A. Consiglio**: A further exception to the Kutta-Joukowski theorem. The case of Joukowski's pisciform obstacle, with a single cuspidal point, is considered.—**Luisa Pelosi**: A new demonstration of a theorem of Painlevé-Levi-Civita on dynamic equations.—**Anna Eredia**: The coefficient of persistence of rainy days. The probability of the occurrence of rainy days, singly or in groups, was studied for Hamburg (1876-1900) by Grossmann, who, on the assumption that the various groupings were equally probable, derived formulæ for calculating the mean number of rainy days out of two, three, or more consecutive days. The values so calculated did not, however, agree with observations made over a considerable number of years, a résult which was recently confirmed by Besson in the case of Paris, and by Domingo y Quilez in that of Saragossa. For Rome, the author finds that the coefficient of persistence of rain varies throughout the year, the maximum being in March and the minimum in July. The coefficient of probability of rain increases with increase in the preceding number of wet days, up to five in the case of Saragossa and to four in that of Rome.—**E. Segrè**: Intensity of the lines in the Raman effects of diatomic molecules. The quantum mechanical formula for the intensity of the Raman lines for the molecule $O_2$ is explained and is found to furnish results in good agreement with the experimental values.—**B. Rossi**: The action of the counter tube of Geiger and Müller.—**G. Racah**: An example of the quantistic treatment of an interference phenomenon.—**A. Ostrogovich**: Investigations on γ-triazines: synthesis of phenylaminohydroxytriazine. This compound may be synthesised by the interaction of benzamidine hydrochloride on guanylcarbamide acetate, and it seems likely that other aminohydroxytriazines may be similarly obtained.—**A. Debenedetti**: The determination of plagioclases by measurement of the angles of extinction in the zone normal to (010).—**Giulio Cotronei and Aldo Spirito**: Zoological constitution and grafting (3). New experiments on Anura and Urodeles.—**M. Comel**: Studies on parathyreoprive syndrome (2). Preventive action of irradiated ergosterol in excessive doses.

### SYDNEY.

**Linnean Society of New South Wales, July 30.**—**J. R. Malloch**: Notes on Australian Diptera (25). This paper contains (*a*) additional notes on Ortalidæ, Sapromyzidæ, Clusioididæ, and Neottiphilidæ, (*b*) a revision of the Calliphorid subfamily Metopiinæ, and (*c*) some notes on Empididæ, with a key to the subfamilies. Thirty species are dealt with, fifteen of which are described as new. Three genera of Metopiinæ are also described as new. Keys are given for separation of the genera of Metopiinæ and species of *Tapeigaster*, *Miltogramma*, and *Protomiltogramma*.—**Rev. H. M. R. Rupp**: Notes on the autumn orchids of the South Maitland coalfields. Notes on nine species of *Pterostylis* and *Acianthus exsertus*. One species of *Pterostylis* is described as new.—**A. A. Lawson**: The origin of endemism in the angiosperm flora of Australia. This paper gives the author's observations on the sterility of various members of the Proteaceæ and Myrtaceæ. The percentage sterility of the pollen is very high in some types, amounting to as much as 95 per cent. The pollen sterility is generally associated with low seed-output. The view is expressed that the sterility of the pollen is the result of natural hybridisation.

## Official Publications Received.

### BRITISH.

Department of Scientific and Industrial Research. Building Science Abstracts. Vol. 3 (New Series), No. 8-9, August-September 1930. Abstracts Nos. 1496-1853. (London: H.M. Stationery Office.) 1s. 6d. net.

Indian Central Cotton Committee: Technological Laboratory. Technological Bulletin, Series B, No. 7: The Weight per Inch of Fibres of Different Lengths, and the Numbers of Fibres of Different Lengths per Seed, for each of the Standard Indian Cottons. By R. L. N. Iyengar and Dr. A. J. Turner. Pp. ii+24. 8 annas. Technological Bulletin, Series B, No. 8: The Foundations of Yarn-Strength and Yarn-Extension. Part 3: The Clinging Power of Cotton. By Hariras Navkal and Dr. A. James Turner. Pp. ii+13. 8 annas. (Bombay.)

University of London: University Extension and Tutorial Classes Council. University Extension Lecture Courses and University Tutorial Classes, Session 1930-31. Pp. 45. (London.)

Commonwealth of Australia: Council for Scientific and Industrial Research. Bulletin No. 44: Investigations on "Spotted Wilt" of Tomatoes. By Geoffrey Samuel, J. G. Bald and H. A. Pittman. Pp. 64. (Melbourne: H. J. Green.)

Transactions of the Optical Society. Vol. 31, No. 3, 1929-30. Pp. iv+113-168. (London.) 10s.

Western Australia. Annual Progress Report of the Geological Survey for the Year 1929. Pp. 38+45 plates. (Perth: Fred. Wm. Simpson.)

Ceylon. Part 4: Education, Science and Art (D). Administration Report of the Acting Director of Agriculture for 1929. By Dr. W. Small. Pp. D28. (Colombo: Government Record Office.) 55 cents.

Indian Journal of Physics, Vol. 5, Part 2, and Proceedings of the Indian Association for the Cultivation of Science, Vol. 14, Part 2. Conducted by Sir C. V. Raman. Pp. 113-236. (Calcutta.) 2.4 rupees; 3s.

South Australia. Department of Mines: Geological Survey of South Australia. Bulletin No. 14: Geological Structure and other Factors in relation to Underground Water Supply in portions of South Australia. By R. Lockhart Jack. Pp. 48+4 plates. (Adelaide: Harrison Weir.)

### FOREIGN.

University of Washington Publications in Anthropology. Vol. 3, No. 2: Mythology of Southern Puget Sound. By Arthur C. Ballard. Pp. 31-150. 1 dollar. Vol. 4, No. 1: The Indians of Puget Sound. By Hermann Haeberlin and Erna Gunther. Pp. 84+2 plates. 1 dollar. (Seattle, Wash.: University of Washington Press.)

U.S. Department of Commerce: Coast and Geodetic Survey. Special Publication No. 168: Progress of Work in Terrestrial Magnetism of the U.S. Coast and Geodetic Survey, July 1, 1927, to June 30, 1928. By Daniel L. Hazard. Pp. 6. (Washington, D.C.: Government Printing Office.) 5 cents.

Proceedings of the American Academy of Arts and Sciences. Vol. 64, No. 9: The Joule-Thomson Effect in Air. Second Paper. By J. R. Roebuck. Pp. 287-334. 90 cents. Vol. 64, No. 10: Diffuse Matter in Interstellar Space. By J. S. Plaskett. Pp. 335-346. 45 cents. Vol. 64, No. 11: A Photographic Investigation of Twenty-five Southern Cepheid Variable Stars. By Harlow Shapley. Pp. 347-464. 1.70 dollars. (Boston, Mass.)

Koninklijk Magnetisch en Meteorologisch Observatorium te Batavia. Jaarverslag 1929. Pp. 25. (Weltevreden: Landsdrukkerij.)

Journal of the Faculty of Agriculture, Hokkaido Imperial University, Sapporo, Japan. Vol. 27, Part 1: Vergleichende Untersuchungen über die Qualitäten, insbesondere die Elastizität und Festigkeit der Tannen- und Fichtenhölzer Hokkaidos. Von Masayuki Ohsawa. Pp. 225. Vol. 28, Part 2: Ein Beitrag zur Kenntnis der Gattung Rhizopus, II. Von Yohihiko Yamamoto. Pp. 103-327. (Tokyo: Maruzen Co., Ltd.)

Monographs of the Rockefeller Institute for Medical Research. No. 23: The Treatment of Human Trypanosomiasis with Tryparsamide; a Critical Review. By Dr. Louise Pearce. Pp. 339. (New York City). 2 dollars.

### CATALOGUE.

Supplément au Catalogue de Photographies Documentaires. Quatrième édition. Pp. 144+8 planches. (Paris: Jacques Boyer.)

## Diary of Societies.

*FRIDAY*, October 17.

Institution of Municipal and County Engineers (North-Western District) (at Liverpool), at 2.

Physical Society (at Imperial College of Science), at 5.—J. P. Andrews: (a) A Simple Approximate Theory of the Pressure between Two Bodies in Contact; (b) Experiments on Impact; (c) Observations on Percussion Figures.—Dr. R. Hase: Some Physical Radiometric Investigations of Technical Interest.

Institution of Mechanical Engineers, at 6.—L. St. L. Pendred: Presidential Address.

Society of Dyers and Colourists (Manchester Section) (at 36 George Street, Manchester), at 7.—F. Scholefield: Chairman's Address.

Society of Chemical Industry (South Wales Section) (jointly with Institute of Chemistry) (at Thomas' Café, Swansea), at 7.—E. E. Ayling: Some Applications of the Electronic Theory in Organic Chemistry.

Iron and Steel Institute (Glasgow Section, jointly with West of Scotland Iron and Steel Institute) (at Royal Technical College, Glasgow), at 7.15.—R. Hamilton: Presidential Address.—Discussion on papers by H. C. Wood: Open-hearth Furnace Steelworks: a Comparison of British and Continental Installations and Practice; and J. Šárek: What Reasons compelled the Prague Ironworks to Introduce Thin-walled Blast-furnaces.

British Electrical Development Association (at Royal Society of Arts), at 7.30.—Lt.-Col. W. A. Vignoles: An American Tour and Experiences.

Junior Institution of Engineers, at 7.30.—T. H. Flowers: The London Automatic Telephone System.

Royal Society of Medicine (Obstetrics Section), at 8.—Dr. G. I. Strachan: Vaginal Metastases in Uterine Carcinoma.—Dr. W. H. F. Oxley: The Organisation and Methods of Practice of the East-End Maternity Hospital.

Royal Society of Medicine (Electro-Therapeutics Section), at 8.30.—Prof. J. M. W. Morison: Radiology—its Progress and Future (Presidential Address).

*MONDAY*, October 20.

British Psychological Society (Education Section) (at London Day Training College), at 6.—Dr. Barbara Dale: An Investigation on the Use of Intelligence Tests with University Students.

Institution of Mechanical Engineers (Graduates' Section, London), at 6.45.—A. E. Hamblin: Mass Production of Tin Containers.

Institution of Electrical Engineers (Mersey and North Wales (Liverpool) Centre) (at Liverpool University), at 7.—A. J. Pratt: The Development of the Telephone System.

Hunterian Society of London (at Simpson's Restaurant, Cheapside), at 7.15.—Prof. A. W. Sheen: The School of Health (Presidential Address).

Keighley Textile Society (at Kiosk Café, Keighley), at 7.30.—J. Starkie: Artificial Silk Weaving.

*TUESDAY*, October 21.

Royal Geographical Society (in New Hall), at 3.—Reception, and Inauguration of Centenary Proceedings.

Royal Society of Medicine, at 5.30.—General Meeting.

Zoological Society of London, at 5.30.—Secretary: (a) Report on the Additions to the Society's Menagerie during the months of May, June, July, August, and September 1930; (b) Exhibition of Photographs of Elephants taken by Mr. M. A. Wetherall in the Belgian Congo.—Dr. S. M. Manton: Exhibition of Photograph of a Living *Anaspides tasmaniæ*.—Miss Rachael M. Renton: On the Budding of a *Scyphistoma*.—Dr. W. H. Thorpe: The Biology, Post-embryonic Development, and Economic Importance of *Cryptochætum iceryæ* Will. (Diptera, Agromyzidæ) parasitic on *Icerya purchasi* (Coccidæ, Monophlebini).—Baron Francis Nopcsa: Notes on Stegocephalia and Amphibia.—P. Gray: The Attachments of the Urodele Rib to the Vertebra and their Homologies with the Capitulum and Tuberculum of the Amniote Rib.—Dr. C. Walter: Report on the Hydracarina (Mr. Omer-Cooper's Investigation of the Abyssinian Freshwaters (Dr. H. Scott's Expedition)).

Royal Photographic Society of Great Britain, at 7.—J. D. Johnston: Presidential Address.

Royal Geographical Society (in New Hall), at 8.30.—Centenary Meeting: Addresses on the History of the Society by Sir Charles Close (President), D. Freshfield, Sir Francis Younghusband, the Marquess of Zetland, and Dr. H. R. Mill.

*WEDNESDAY*, October 22.

Royal Geographical Society (in New Hall), at 10.30.—Papers on The Habitable Globe by Invited Geographers, British and Foreign.

Institute of Fuel (in Incorporated Accountants Hall, Victoria Embankment), at 11 a.m.—Sir David Milne-Watson: Presidential Address.—J. Lubbock: The Industrial Uses of Fuel Oil.—Dr. E. W. Smith: The Use of Coke Breeze for Industrial Purposes.

Liverpool Engineering Society (at 9 The Temple, Liverpool), at 6.30.—J. L. Adam: Notes on Surveys of Ships.

Leicester Literary and Philosophical Society (Chemistry Section) (at College of Technology, Leicester), at 8.—S. F. Burford: Progress of Chemistry.

Textile Institute (Midland Section) (at University College, Nottingham), at 8.—A. N. Shimmin: Some Reactions of Foreign Competition on British Trade.

British Psychological Society (Medical Section) (at Royal Society of Medicine), at 8.30.—Dr. T. R. Hill: Emotion from the Neurological Standpoint.

*THURSDAY*, October 23.

Royal Geographical Society (in New Hall), at 10.30.—Continuation of papers on The Habitable Globe.—At 3.—Incidents in the History of Exploration: Brief papers by Lord Lugard, Sir Martin Conway, Sir Francis Younghusband, Sir Halford Mackinder, Col. H. Bury, J. M. Wordie, and others.

Institute of Fuel (in Incorporated Accountants Hall, Victoria Embankment), at 10.45 a.m.—S. B. Freeman, Dr. W. W. M. Meijer, W. J. Muller, W. L. Roxburgh: Symposium on Fuel Problems in the Mercantile Marine.

Institution of Electrical Engineers, at 6.—C. C. Paterson: Presidential Inaugural Address.

Child-Study Society (at Royal Sanitary Institute), at 6.—Dr. J. Kerr: The Whole Child.

Royal Aeronautical Society (at Royal Society of Arts), at 6.30.—F. W. Meredith: Air Transport in Fog.

Chemical Society, at 8.—A. W. Chapman: Dynamic Isomerism Involving Mobile Hydrocarbon Radicals. Part II. The Intramolecular Character of the Amidine Rearrangement.—A. W. Chapman and C. H. Perrott: Dynamic Isomerism Involving Mobile Hydrocarbon Radicals. Part III. Some Effects of Substitution on the Velocity of Interchange and Position of Equilibrium of Isomeric Triarylbenzenylamidines.—G. G. Davies, Prof. I. M. Heilbron, and W. M. Owens: The Unsaponifiable Matter from the Oils of Elasmobranch Fish. Part VII. The Synthesis of α-glyceryl Ethers and the Constitution of Batyl, Selachyl, and Chimyl Alcohols.—Prof. I. M. Heilbron and D. G. Wilkinson: The Unsaponifiable Matter from the Oils of Elasmobranch Fish. Part VIII. The Structure of the Naphthalene Hydrocarbon derived from Squalene.—Prof. I. M. Heilbron and F. S. Spring: Studies in the Sterol Group. Part X. Hydrocarbons of the Ergosterol Series and the Nuclear Structure of Ergosterol.—Miss N. I. Fisher and Miss F. M. Hamer: A General Method for the Preparation of Thiocyanine Dyes. Some Simple Thiocarbocyanines.

*FRIDAY*, October 24.

North-East Coast Institution of Engineers and Shipbuilders (at Newcastle-upon-Tyne), at 6.—J. McGovern: Presidential Address.

Institution of Mechanical Engineers (Informal Meeting), at 7.—J. L. Hodgson and others: Discussion on What are the Desirable Objectives of the Age of Power?

Junior Institution of Engineers, at 7.30.—A. P. Morris: Bitumen Emulsions, with Particular Reference to their Use on Indian Roads.

Leicester Textile Society (at Victoria Hall, Leicester), at 7.30.—E. Lomas: Pure Silk Manufacture.

Institution of Chemical Engineers (Graduates' and Students' Section).—J. E. Duckham: Lubrication as applied to Chemical Engineering.

Society of Chemical Industry (Liverpool Section) (at Liverpool University).—Dr. P. Lewis-Dale: Chemistry in the Service of the Railway.

Association of Economic Biologists.

### PUBLIC LECTURES.

*FRIDAY*, October 17.

London Hospital (in Bearsted Clinical Theatre), at 4.15.—H. S. Souttar: Radium in the Service of Surgery (Schorstein Memorial Lecture).

*SATURDAY*, October 18.

Horniman Museum (Forest Hill), at 3.30.—Prof. J. R. Ainsworth Davis: The Uses of a Tail.

*MONDAY*, October 20.

Imperial College of Science and Technology, at 5.30.—Prof. K. Freudenberg: Some Aspects on the Structure of Cellulose and other Polysaccharides; with Remarks on the Constitution of Lignine. (*Oct. 20 and 21.*)—Researches on the Constitution of Insuline. (*Oct. 22.*)

University College, London, at 5.30.—W. N. Weech: More Roman Towns in North Africa.

*TUESDAY*, October 21.

King's College, London, at 11 a.m.—S. P. Turin: The Economic Geography of U.S.S.R.: Population.

Gresham College, at 6.—Sir G. Newman: Physic. (Succeeding Lectures on Oct. 22, 23, and 24.)

*WEDNESDAY*, October 22.

Royal Institute of Public Health, at 4.—Prof. W. S. Lazarus-Barlow: The Prevention of Pre-Cancerous States and the Arrest of Cancer.

British Science Guild (at Liverpool University), at 5.30.—Lt.-Col. Sir David Prain: Science Discipline (Alexander Pedler Lecture).

*THURSDAY*, October 23.

Royal Institute of Public Health, at 4.—A. Goodman: Some Medico-Legal Aspects of Contraception.

London School of Economics and Political Science, at 5.—Prof. L. T. Hogben: Some Biological Aspects of Population.

London School of Hygiene and Tropical Medicine (Public Health Division), at 5.—Sir Leonard Hill: Clothing and Climate.

British Medical Association (Hastings Hall, Tavistock Square), at 5.15.—Dr. F. Bach: Rheumatism: its Significance in Youth and Middle Age (Chadwick Lecture).

Bedford College for Women, at 5.15.—Miss L. Grier: Changes in Occupations and Leisure of Women from 1830 to 1930.

King's College, London, at 5.15.—Dr. A. D. Lindsay: Hegel and the German Idealists. (Social and Political Ideas of some Representative Thinkers of the Age of Reaction and Reconstruction.)

*FRIDAY*, October 24.

University College, London, at 5.30.—Prof. A. Penck: The Relations of Europe and Central Asia. (Succeeding Lecture on Oct. 27.)

*SATURDAY*, October 25.

University of Bristol (in Henry Herbert Wills Physical Laboratory), at 11.45 a.m.—Prof. J. Franck: Relations between Spectroscopy and Chemistry (Henry Herbert Wills Memorial Lecture).

Horniman Museum (Forest Hill), at 3.30.—Dr. C. Ainsworth Mitchell: Stories told by Hairs and Fibres.