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The Development Fund.

IN a recent leading article (NATURE, February 16) on the subject of the Geddes Report in its relation to Education and Research, allusion was made to the seemingly precarious condition of the above Fund. While it is a matter for congratulation that the Chancellor of the Exchequer, agreeing with the views which we expressed, rejected the suggestions that the funds provided by Parliament for *additional* research should be used to fill a gap to be created in *existing* expenditure, he did nothing to allay the anxiety created by the depletion of the Development Fund. A White Paper (No. 15, price 3*d.* net) just published contains the accounts of this Fund for the year ended March 31, 1921. It appears that the surplus at the credit of the Fund on that date was 1,170,000*l.*; but of this about one-third represents outstanding loans, and the amount available for current needs on April 1 of last year was only 795,000*l.* Referring to the Report of the Commissioners for the same year we find it stated that "against this balance must be set liabilities . . . in respect of advances recommended up to that date . . . there was a balance, therefore, of 250,000*l.* for annual advances required to meet the *cost of existing* schemes."

The published accounts show that in the year 1920–21 alone advances totalling 568,000*l.* were made, and, so far as it is possible to interpret the accounts, at least 300,000*l.* of this sum was required to meet the recurrent cost of existing schemes. It seems doubtful, therefore, whether the balance available on April 1 of last year was sufficient to meet the normal liabilities of the Fund for the succeeding twelvemonths. There is, however, a reserve not disclosed in the accounts, for in their Report the Commissioners go on to say: "In the estimates . . . for the following year (1920–21) Parliament voted a similar amount [1,000,000*l.*] for the general purposes of the Development Fund. In view of the urgency of restricting issues from public funds, the Commissioners agreed that the grant voted should be surrendered . . . on the understanding that Parliament would be invited to revote the amount in the year 1922–23." But in the statements that have been published from time to time in connection with the economy campaign, this sum of one million has not been specified. It is to be hoped that when Parliament is "invited" to provide the money it will be realised that, without it, the whole organisation of research in the sciences bearing on agriculture and fisheries must collapse.

With the help of the Development Fund a number of research institutions have been established on a permanent basis, and yet there is no guarantee that the money required for their maintenance will be forthcoming even one year hence. Under our Constitution no continuing guarantee can be given, but it might be considered whether greater stability would not be secured by transferring the liability for all permanent schemes to a regular vote head, thus leaving the Fund for real "development" purposes.

The Teaching of Physics.

AT the Orono meeting of the New England section of the Society for the Promotion of Engineering Education held recently, the question was discussed, "What is the matter with physics teaching?" We have received two of the opening papers, from which it appears that in American technical colleges and universities, engineering students dislike and even despise the physics taught them. For this the teacher is blamed, on one hand for not being sufficiently precise and exact in his definitions and reasoning, and on the other for trying to force on the engineer the C.G.S. system of units. Most of the illustrations of bad teaching are taken from dynamics, an accurate knowledge of which is, of course, indispensable to the really scientific engineer.

The trouble is also traced to some extent to the academic text-book, which teems with artificial problems having little relation to what is met with in practice. Students whose minds are gripping the mechanism of water-wheels, pumps, and engines are too often expected to find satisfaction in the study of levers, "simple machines," and systems of weightless and frictionless pulleys. It appears, moreover, that the text-book is being more and more neglected, and, as one writer puts it, "physics has degenerated into interminable class-room coaching, making our teaching not only very exhausting, but also frightfully expensive, and greatly weakening the *moral* of our students."

There is certainly an element of truth in this criticism. In many universities students get so much direct teaching by lecture, by tutorial expansion, and by the performance of routine experiments to printed orders, that they have little time or energy left for real effective thinking. There is a tendency to forget that a mere knowledge of apparatus and of methods of experimenting does not make a physicist. The physical imagination should be trained, and the highest powers of mind called into play, and the student should be encouraged to get into living touch with the creative literature of the subject. This, of course, is not easy, especially when the classes are large. What is wanted is an accessible reading-room fully supplied with the journals and other publications in which progressive work is recorded. Students, if not overburdened by an excess of class and laboratory attendance, would soon come to appreciate the value and delight of thus getting into touch with the vital problems of the day.

Nevertheless, in the hands of a good teacher there is nothing to compare with the lecture as a means of giving a systematic theoretic view of the whole science treated, and there is no better corrective to the extreme and unscientific utilitarianism which makes many a student think that he is being taught what will be of no value to him. Technical schools may narrow their teaching to what seem at the time to be the absolute necessities, but a university is intended to give engineering students an all-round training in the fundamental sciences of mathematics, natural philosophy, and chemistry. Without these an engineer is only half equipped for his calling.

The Principles of Distillation.

Distillation Principles and Processes. By Prof. Sydney Young, with the collaboration of various authors. Pp. xiv+509. (London: Macmillan and Co., Ltd., 1922.) 40*s.* net.

THIS book is a new and amplified edition of the author's well-known treatise on "Fractional Distillation," first published in 1903. Prof. Sydney Young is an acknowledged authority on the subject on which he writes, and for many years prior to the appearance of the first edition of his work, the principles underlying the separation of substances by distillation had been investigated by him and the results communicated to various scientific societies. But his book embodied not only his own experience. Everything that was known at that period concerning the science and art of distillation was duly recorded and discussed, and the relative merits of the various still-heads and other forms of apparatus employed in the processes of fractional distillation were carefully inquired into and compared. The rapid development of organic chemistry, pure and applied, during the latter half of the nineteenth century was the immediate cause of the attention which the subject then received. Distillation was practically the only means available for the isolation of the constituents of mixed liquids. The art of distillation is, of course, as old as any chemical process, but the principles upon which its efficient application as a method of separation of complex liquids depend, were very imperfectly understood. Prof. Young's book was the first systematic attempt to explain these principles and to illustrate their bearing upon laboratory and technical procedure. It has not only been of great use to operative chemistry, but it has served to indicate many points of theoretical interest concerning the thermal behaviour of substances which, although they may have no immediate utilitarian value, are certain to influence practice in the future.

During the two decades which have elapsed since the appearance of the first and second editions of this work, a considerable body of additional information has been accumulated concerning its subject-matter, not, perhaps, so much in the elucidation of fundamental principles as in the compilation of accurately observed thermal values upon which the various mathematical formulae which seek to generalise the facts of distillation depend. The present edition differs from its predecessor in one important feature: it deals more particularly with the technical applications of distillation. The book, in fact, is divided into two main sections. The first is practically a reprint of the first edition on "Fractional Distillation," extended and brought up to date by the inclusion of all material facts which have been made known during the last twenty years. For much of this information we are indebted to British workers, and the results of the valuable investigations of Wade and Finnemore and of Wade and Merriman are described in adequate detail. Wade's unfortunate death in the full tide of his intellectual vigour, when all his energies were concentrated upon the development of an inquiry with which by training and aptitude he was specially fitted to cope, was a serious loss to science.

An important addition to the work is a chapter on sublimation. As the author points out, there is no essential distinction between distillation and sublimation, although at first sight the dissimilarity of the two operations would seem to imply a difference. The term distillation denotes the volatilisation of a substance and its condensation and recovery, drop by drop: by sublimation is usually understood the direct passage from the gaseous to the solid state without intermediate liquefaction. But intermediate liquefaction may be induced by pressure. If, therefore, the process be effected under pressure, liquefaction will occur and the substance will ultimately boil, although on cooling the vapour may pass directly to the solid state. The conditions under which distillation and sublimation become identical operations were first explained by James Thomson, though even now the triple point pressures of only a few substances are accurately known. Indeed, there is ample room for a more extended investigation on the relation of this factor to the other thermal constants of a body. The author describes very shortly a few typical cases of sublimation, such as iodine, sulphur, arsenious oxide, and ammonium chloride, with illustrations of the plant employed, and explains the principles involved in the several instances. As these are not usually indicated in text-books, the attention of teachers may well be directed to them.

The second section of the book, dealing with certain technical and large-scale operations of distillation, occupies about half the volume, and the examples selected for description have been entrusted to chemists with practical experience of their working. They comprise:

(1) Distillation of Acetone and *n*-Butyl Alcohol on the Manufacturing Scale. By Dr. Joseph Reilly and the Hon. F. R. Henley.

(2) Distillation of Alcohol on the Manufacturing Scale. By the Hon. F. R. Henley and Dr. Reilly.

(3) Fractional Distillation as applied in the Petroleum Industry. By James Kewley.

(4) Fractional Distillation in the Coal-Tar Industry. By Dr. T. Howard Buller.

(5) The Distillation of Glycerine. By Lieut.-Col. E. Briggs.

(6) The Distillation of Essential Oils. By Thos. H. Durrans.

These, it will be seen, comprise all the main technical processes with which British chemists, at least, are concerned.

Considerations of space preclude any detailed account of these several sub-sections. The descriptions are such as will appeal to the chemical engineer or works-manager. They are concise, and deal mainly with the practical aspects of the various processes, and the illustrations—chiefly in the form of line-drawings—of the plant employed, will commend themselves to those actually interested in the different industries. There is, as might be anticipated when several writers are concerned with the application of the same physical principles, a certain amount of repetition and overlapping. This is unavoidable, and is not to be deprecated even although these matters are adequately dealt with in the theoretical section of the work. Their restatement, in fact, is required in any adequate account of their bearing upon the particular technical process described.

The book is remarkably free from typographical errors, and we have noticed only a few mistakes—mainly in the spelling of proper names: thus Speyer (p. 29) should read Speyers, and Dufton (p. 138) is erroneously printed Dutton. The work indeed is a credit to all concerned in its production, and well sustains the position it already holds as the chief authority on the subject of distillation. In its present extended form it affords an admirable illustration of the benefits which follow the intelligent application of physical principles to chemical processes on a manufacturing scale.

Mathematical Analysis.

(1) *The Theory of Functions of a Real Variable and the Theory of Fourier's Series.* By Prof. E. W. Hobson. Second edition, revised throughout and enlarged. Vol. 1. Pp. xvi+671. (Cambridge: At the University Press, 1921.) 45*s.* net.

(2) *Introduction to the Theory of Fourier's Series and Integrals and the Mathematical Theory of the Conduction of Heat.* By Prof. H. S. Carslaw. Second edition, completely revised. Vol. 1, *Fourier's Series and Integrals.* Pp. xi+323. (London: Macmillan and Co., Ltd., 1921.) 30*s.* net.

(3) *A Treatise on the Integral Calculus, with Applications, Examples, and Problems.* By J. Edwards. Vol. 1. Pp. xxi+907. (London: Macmillan and Co., Ltd., 1921.) 50*s.* net.

(1) THE first edition of Prof. Hobson's treatise fell naturally into two parts. The first five chapters were occupied with the theory of aggregates, the general theory of functions, and the theory of integration, while the last two dealt with the theory of series, and in particular with Fourier's series. It is the first five chapters which have developed into the present volume. It was inevitable that a great deal of the book would have to be rewritten, for the theory has developed very rapidly; there was a mass of recent research to be incorporated, and much of the older work has been definitely superseded. The preparation of a new edition must have been a very long and heavy piece of work, and Prof. Hobson is to be congratulated on the progress he has made with so formidable a task.

There is a singular contrast between the two great branches of the theory of functions. The complex theory has always been popular. The power of its weapons is obvious; its methods have a striking, if somewhat illusory, simplicity; and it is fascinating to investigators, to teachers, and to students alike. It is unlikely that the real theory, more abstract and in many ways more difficult, will ever be so generally attractive. Still, times have changed, very largely through the influence of Prof. Hobson himself. The theory is studied seriously even in England, and ignorance of fundamentals is no longer regarded as proof of physical insight or geometrical intuition. Prof. Hobson has every right to be satisfied with his share in this salutary revolution.

It must be admitted that there was some excuse for the conservative mathematician of twenty years ago, and his sneers at a theory which he was too lazy to try to understand. The older theory, the theory of 1900, was not only abstract and difficult, but in some ways really unattractive. There was too little simple and positive doctrine, too many intricate and irritating exceptions. Little could be proved, and the theorems which it was possible to prove were difficult to state in a terse and striking form. The theory of content in particular was obviously imperfect. The theory as a whole seemed dried up and infertile; it is easy to see now how grievously it stood in need of some refreshing storm.

All this has been changed by the rejuvenating influence of the ideas of Borel and Lebesgue. The storm has broken, and the ground has become fresh and fertile once more. There is, indeed, no other region of pure mathematics that has experienced so drastic a revolution. Prof. Hobson's book is the only English book which contains a systematic statement of the revolutionary doctrine, and it is this, above all else, that gives it its unique position.

The importance of the new theories of measure and integration is generally admitted, but their effect on the theory of functions is still very widely misunderstood. They are much more general than the older theories, and it is supposed that, being more general, they must be much more complicated and more difficult to understand. The result is that many mathematicians are too frightened to make any serious attempt to comprehend them. This attitude of panic is based on a complete misapprehension. It is not true that the new theories are much more difficult than the old. It is by no means always the most general and the most abstract that is the most difficult to understand. The trouble with the older theory lay not so much in the inherent difficulty of the subject-matter as in the complexity and clumsiness of the results. The modern theory, in acquiring generality, has acquired symmetry, terseness, and to a great extent simplicity as well. It possesses the æsthetic qualities that are characteristic of a first-rate mathematical science. Its theorems can be stated in a concise and arresting form, and make that appeal to the imagination which enables them to be mastered and remembered. It is much easier to be a master of the new theories than it was to be a master of the old, and it is also much more necessary. A young mathematician who elects to remain in ignorance of them is certain to regret his laziness or obstinacy in years when it is more difficult to learn.

It is, then, Prof. Hobson's chapters on measure (chap. 3) and integration (chaps. 6-8) that are unquestionably the most important in the book. His treatment is much more comprehensive and encyclopædic than that of any other writer. He has three serious rivals, de la Vallée Poussin, Carathéodory, and Hahn. Hahn may be disregarded for the present, as the second volume of his "Theorie der reellen Funktionen," in which the theory of integration is to be developed, has not yet appeared. The works of de la Vallée Poussin ("Cours d'analyse infinitésimale," second and third editions, 1909, 1912, 1914; "Intégrales de Lebesgue, fonctions d'ensembles, classes de Baire," 1916) continue to provide the best introduction to the theory. Between Carathéodory and Prof. Hobson it is unnecessary to discriminate, for both are essential for the systematic study of the subject. It is sufficient to say that there is a great deal in this volume which Carathéodory does not touch.

Chaps. 1, on number, and 4, on transfinite numbers and order-types (chap. 3 of the first edition) have not been greatly changed. We must confess that it has always been this part of the book that we like the least. Prof. Hobson often allows himself to use language which suggests the Oxford philosopher rather than the Cambridge mathematician. "The mind" maintains its position in the first sentence of chap. 1; "objects for thought" are "postulated" on p. 29; a "fundamental difference of view on a matter of Ontology" is mentioned on p. 249. We have an uneasy feeling that if one scratched the mathematician one might find the idealist, and that all these discussions, and especially those which concern the "principle of Zermelo," ought to be stated in a sharper and clearer form.

Chaps. 2 and 3 are concerned with sets of points, the theory of content and measure having very wisely been separated from the descriptive theory. The greatest difficulty is to distinguish the theorems for which Zermelo's axiom is required. We could make some criticisms of detail—we found difficulty, for example, in disentangling the proof that the measure of a measurable set satisfies the postulate (3) of p. 159, tied up as it is with the corresponding proof for the more difficult postulate (4)—but it would be ungracious to insist on such small criticisms of the most comprehensive presentation of the theory.

In chap. 5, on functions of a real variable (chap. 4 of the first edition), there are very many important additions. The ideas of absolute (p. 276) and approximate (p. 295) continuity are introduced. The treatment of functions of bounded variation (we are glad to find Prof. Hobson now adopting the ordinary language) has been materially simplified, and there is a new section (pp. 318-320) on rectifiable curves. The latter part of the chapter includes an account of some of the most recent work of Denjoy, G. C. Young, and W. H. Young concerning derivatives. Above all, there is a discussion of implicit functions, omitted somewhat unaccountably from the earlier edition. This is a most welcome addition, but we are surprised that Prof. Hobson does not state the fundamental theorem (p. 407) in its most general form. No reference to derivatives is necessary, as was made clear by Young, and a theorem more general than Prof. Hobson's is to be found in so elementary a book as the reviewer's "Pure Mathematics."

Finally, chaps. 6-8 contain the theory of integration, and it is here that we find the most that is new. These chapters are naturally far better than the corresponding parts of the first edition, both in completeness and in logical arrangement, for the first edition appeared at the awkward moment when Lebesgue's ideas were new, and the consequences of his work had not been developed to their conclusion. It may be questioned whether the space (eighty pages) devoted to the Riemann integral is not excessive, since so much of the theory is now of historical or didactic interest only; but Prof. Hobson's object is, of course, to be complete. The importance of the Stieltjes integral is fully recognised in this edition. The last chapter ("Non-absolutely convergent integrals"), dealing as it does with the extreme limits of generalisation of which, in the hands of Denjoy and of Young, the notion of an integral has so far proved to be capable, is very heavy reading; but to have given the first systematic account of these generalisations is in itself a most important achievement.

It is to be hoped that we shall not wait long for the appearance of the second volume, and the completion of a work which has added so much, not only to the personal reputation of the author, but to the status of English mathematics.

(2) Prof. Carslaw's book was conceived on a much less ambitious scale than Prof. Hobson's, but he too has had to rewrite it and turn one volume into two. This first volume contains pure mathematics only, and there is no reference to any physical phenomenon after the introduction. It is, in short, a treatise on analysis, restricted within certain limits, and written with a special end in view.

Prof. Carslaw confines himself quite rigidly and consistently within the limits which he has chosen. It was necessary to have definite limits, but we do not agree entirely with his judgment in selecting them. We think that he has made them too narrow, and that he would have written a still better and more attractive book if he had allowed himself a rather wider scope. It is a very good book even as it is, for it is accurate and scholarly, it contains a mass of most interesting and important theorems which it would be difficult to find collected in an equally attractive form elsewhere, and it is written in an admirably clear and engaging style. It also contains an excellent bibliography of the subject.

Prof. Carslaw has gone too far, however, in his anxiety to eliminate the refinements of the modern theory of functions. For example, the notion of a function of bounded variation is quite explicitly and deliberately excluded (p. 207). The only functions admitted—if we confine our attention, for simplicity of statement, to bounded functions—are those which satisfy Dirichlet's famous condition; they have at most a finite number of maxima and minima within the interval considered. Now there is a serious logical objection to a treatment of Fourier's series in which this class of functions is taken as fundamental, an objection which even a physicist might feel. It is an artificial and not a natural class, since it does not form a group for the elementary operations. Neither the sum nor the product of two functions of the class is in general a function of the class; and it is difficult to see why, if a physicist is interested in two functions, he should not also be interested in their sum.

Prof. Carslaw alludes to the notion of bounded variation as "somewhat difficult," and so, no doubt, it is. But the necessary analysis, as presented, for example, by de la Vallée Poussin, is certainly not more difficult than a good deal which Prof. Carslaw includes. It is not more difficult, for example, than the second mean value theorem, or the theory of Poisson's integral, or Pringsheim's discussion of Fourier's double integral, of all of which Prof. Carslaw gives a very careful account. In any case a book may be made much easier by the inclusion of a difficult theorem, if it helps to elucidate the theorems which the book already contains.

It is inevitable that an analyst, reading a book like this, should be longing to go further all the time. No account of the theory of Fourier's series can possibly satisfy the imagination if it takes no account of the ideas of Lebesgue; the loss of elegance and of simplicity of statement is overwhelming. We recognise that it would be unreasonable to ask Prof. Carslaw for an account of the modern theories of integration. We hope, however, that, when next he has an opportunity of preparing a new edition, he will remedy the omission which we have emphasised. He should also certainly include the fundamental theorem that the Fourier constants of any integrable function tend to zero (a rather startling omission), and some account of Parseval's theorem. He would thus add greatly to the value of an already valuable book.

(3) Prof. Hobson gives us the mathematics of 1921, and Prof. Carslaw is not far behind him. Mr. Edwards's book may serve to remind us that the early nineteenth century is not yet dead. He directs our attention to "the admirable and exhaustive works of Legendre, Laplace, Lacroix, Jacobi, Serret, Bertrand, Todhunter, etc."; from which he has learnt, for example, that "a limit may be of finite, infinite, or indeterminate value," that "the processes of integration are necessarily of a tentative nature," and that any convergent series may be integrated term by term. Two proofs are offered of the last proposition. In the first it is stated to be valid "provided the series V itself, and the series V formed by the integrations of the separate terms, are both *absolutely convergent*." Mr. Edwards italicises the last condition, but we have no idea why it is inserted, for there is no pretence of making any use of it, nor is its meaning explained.

It is difficult for a reviewer to know what to say about such a book, except that it cannot be treated as a serious contribution to analysis. Twenty years ago it might have been necessary to establish the point in detail; it would be waste of time now, when the battle for accuracy has been won. There is always the danger, however, that a student who reads a text-book may suppose that the statements which it contains are true. We should therefore state explicitly that the "general theorems" asserted in this book are often false, and that, even when they are true, the arguments by which they are supported are generally invalid.

One ought, of course, to judge the book by a different standard, as a storehouse of formulæ useful for instructional purposes. Of such there is an abundance, including a good many which are seldom found in other books, and often entertaining or even important. We may mention Catalan's formula for the surface of an ellipsoid, results concerning roulettes and glissettes, the theorems of Fagnano, Burstall, Graves, MacCullagh, Schulz, and others. The book, in short, may be useful to a sufficiently sophisticated teacher, provided he is careful not to allow it to pass into his pupil's hands.

G. H. Hardy.

Greek and Arab in Medicine.

(1) *Greek Medicine in Rome: The FitzPatrick Lectures on the History of Medicine delivered at the Royal College of Physicians of London in* 1909–10, *with other Historical Essays.* By Rt. Hon. Sir T. Clifford Allbutt. Pp. xiv+633. (London: Macmillan and Co., Ltd., 1921.) 30*s*. net.

(2) *Arabian Medicine: Being the FitzPatrick Lectures delivered at the College of Physicians in November* 1919 *and November* 1920. By Prof. Edward G. Browne. Pp. viii+138. (Cambridge: At the University Press, 1921.) 12*s*. net.

SINCE the great revival of historic interest in the eighteenth century the labour of historians has been directed mainly towards political institutions. Sociological and cultural history have been of much slower growth, and we are only now beginning to be able to treat the history of European life as a whole, to look upon it as one majestic panorama developing from the early Mediterranean culture in which first Egypt, then Crete, then Greece was leader, to the time when Rome herself, in receipt of tributary streams from Syria, Persia, Mesopotamia, and India, acted as the cultural intermediary to the European peoples, and, finally, to the diffusion by those peoples of the infectious elements of the ancient tradition throughout the world. It will thus one day become possible to present this panorama with its various aspects in adequate relation to each other. Mr. Marvin, in his "Living Past," and Mr. Wells, in his "Outline of History," have produced tentative sketches in that direction. Such works point to a time when the history of civilisation, the most absorbing of all topics, will form the humane basis of education. There are, however, large departments in which the material is not yet to hand for this consummation. Especially defective is our record of certain aspects of the development of thought. Formal thought, philosophy, has, it is true, found fairly adequate treatment. A real history of religion is, however, still strangely absent, despite the vast literature which professes to deal with that topic, and the history of psychology is very backward. The history of science, too, presents vast gaps which are sometimes vainly treated as though they represented breaches in continuity of the phenomena rather than breaches in our knowledge, and the two works before us represent the efforts of two eminent scholars in two separate departments to establish continuity across these gaps.

(1) Sir Clifford Allbutt has been distinguished for two full generations and more as an exponent alike of modern scientific medicine and of the scientific

record of Greek antiquity. He brings to this volume, the title of which gives but an inadequate idea of its range, an extent of combined knowledge and experience in these departments that is probably unsurpassed by any other man living.

About half of the book, and this probably the more valuable half, deals with the period of creative activity of the Greek genius. Sir Clifford Allbutt pictures, as perhaps only one of his attainments could, the rise of scientific medicine among the Ionian philosophers of the sixth and fifth centuries before the Christian era, and that process of "separation of medicine from philosophy" which made "science" possible. The earlier philosophers set out to give a picture of the universe both internal and external. They failed because they had not as yet concentrated on the parts which go to make the whole. But their attempt corresponded to an eternal necessity of the human mind. Two and a half millennia have passed. Mankind is now overwhelmed with a vast record in which the details of the parts prevent any vision of the whole. Science, philosophy, and history are each split into a hundred special departments, most of them without adequate relation to the others. Eternal necessity asserts itself again, and the human mind calls for attempts at synthesis. The wheel has turned full circle, and the philosophical, the educational, and the scientific demands of the day echo those needs that Thales sought to satisfy six hundred years before the Christian era.

Sir Clifford Allbutt paints on a big canvas and with the great, sure, sweeping lines that come only to those who have lived a long, full life. His work stands alone in the English language as an attempt to portray, both in outline and detail, the development as a continuous whole of Greek biological and medical thought from its early beginnings to its spread to the confines of the Roman Empire, and to its strange transformation by the new point of view introduced by the decay of the pagan political system and the rise of Christian theology.

This is a high theme which can no more be abstracted by the reviewer than can that of a great epic. The work, like every epic, contains inequalities on which it would be alike ungracious and unnecessary to dwell. But it also contains characteristic and inspiring flashes that often raise it to the level of poetry and make it a real addition to English literature. Not the least characteristic and inspiring of these is Sir Clifford Allbutt's treatment of the idea of inspiration itself and its relation to the ancient doctrine of the *pneuma*.

"To-day," says the author, "as we utter the word *inspiration* we still feel the glow of the spirit which, from the ancient legends of the creation of life to the passages of our modern ethereal telegraphy, from the hauntings of the Great Spirit in primeval man, through the storms of superstition, to the haven of the soul in its purest communion with the Divine, has moulded the whole story of man and embedded itself in his tongue. Yet we shall observe again nevertheless in the history of this, as of all spheres of thought, how a living idea gradually becomes so imprisoned in the letter that its liberty is enthralled in its own formulas. Thus as the brilliant Ionian atomic hypothesis dried up into the arid formulas of the Methodists, as Hippocratean wisdom into Dogmatism, as Empiricism into mere rule of thumb, rational scepticism into Pyrrhonism, so the idea of the pneuma was cribbed in the sectarian Pneumatism."

Sir Clifford will soon be entering his eighty-seventh year, but the vigour of this and many other passages in his remarkable book gives good hope that we may expect much further material from his pen, on topics which he, more than any other living man, is capable of treating with full adequacy.

(2) The learned Sir Thomas Adams professor of Arabic in the University of Cambridge takes up the tale where Sir Clifford Allbutt leaves off. With the fall of the Western Empire Greek science remained in the keeping of the East, and it became progressively orientalised with those changes in the outlook of the Eastern world that may be described as *Byzantinisation*. With the spread of Christianity, and with the advent of schism within the Christian Church, Greek science moved yet further east, and, in its medical aspects, at any rate, was cultivated especially by teachers of the Nestorian sect, by whom much Greek material was turned into Syriac. It was through such oriental versions that Greek medicine passed to the keeping of the Arab-speaking world. The overflow from the Arabian peninsula in the seventh century, and the conquest by the Arabs of the whole of the Near East and the whole of North Africa, the Mediterranean islands, Spain and Southern Italy in the centuries which followed, form one of the most dramatic chapters in world history. The Arabs, great as conquerors and organisers, did not, however, excel in science, and nearly all "Arabian" medical works are the products of men of non-Arab race, Persians, Moors, Jews, and others.

The golden age of Arabian learning culminated between A.D. 750 and 850, the century succeeding the establishment of the Abbasid Caliphate with its metropolis at Bagdad. In the thirteenth century Islamic civilisation suffered an injury from which it never recovered, through Tartar invasion, which destroyed for ever the Caliphate, the unity of the Arabian Empire, and the pre-eminence of Bagdad as a centre of learning. With this fall the hegemony of the intellectual world passed to Europe mainly by means of material translated into Latin from Arabic, often through Hebrew. This material had itself been largely translated from Syriac, and the Syriac versions themselves were derived from Greek, so that Greek learning reached the West at third or fourth hand. But between the eighth and the thirteenth centuries science and learning, literature and culture remained, like civil organisation and military power, mainly with the Arabic-speaking peoples who stretched from India and Persia to the Atlantic seaboard. The learning of this period is described as "Arabian," and must be carefully distinguished from the true "Arab" material which comes only from Arabia.

It is certain medical aspects of this great Arabian civilisation with which Prof. Browne here deals. It is a subject with a vast literature that can scarcely be treated, even in outline, in a hundred and thirty pages. Apart from the actual changes which the medical system of Greece underwent in Arabian hands, and besides the actual contributions of Arabian authors themselves, an adequate history of Islamic medicine would need to treat of the psychological basis of those changes arising in part from the social and political circumstances of the time, in part from the racial characteristics of the Islamic peoples, and in part from the philosophy and general outlook prevalent among them.

The time is still distant when it will be possible to do this, and Prof. Browne, in this admirable little book, has essayed a smaller task. He concentrates on the work of a small number of the most important Arabian physicians, and notably on three Persians, known to the medieval Latins under the names of Rhazes, Haly Abbas, and Avicenna, whose works were the main carriers of the Arabian medical traditions to the West. Avicenna's enormous "Canon" is especially of importance as being—perhaps with the exception of the "Aphorisms" of Hippocrates—the most widely read work on medicine that has ever been written. More interesting perhaps to most readers will be Rhazes, whose memorable treatise on smallpox and measles was the first in which these diseases were differentiated. This work was translated by the late Dr. Greenhill in 1848, but, with that exception, Prof. Browne's is, so far as we know, the only modern book on Arabian medicine in the English language based on first-hand knowledge. It will be valued both on that account and as a very lucid and scientific exposition of a subject which very few besides Prof. Browne himself are qualified to treat.

Charles Singer.

Elementary Meteorology.

(1) *The Rainfall of the British Isles.* By M. de Carle S. Salter. Pp. xiii+295. (London: University of London Press, Ltd., 1921.) 8*s.* 6*d.* net.

(2) *Études Elémentaires de Météorologie Pratique.* By Albert Baldit. Pp. ix+347. (Paris: Gauthier-Villars et Cie, 1921.) 15 francs net.

(3) *Simple Lessons on the Weather for School Use and General Reading.* By E. Stenhouse. Pp. viii+135 +12 plates. (London: Methuen and Co., Ltd., 1921.) 4*s.*

(4) *Handbook of Meteorology: A Manual for Co-operative Observers and Students.* By J. W. Redway. Pp. v+294. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1921.) 24*s.* net.

(1) IN "The Rainfall of the British Isles" Mr. Salter gives a wealth of information that hitherto could be obtained only by searching through the volumes of "British Rainfall." The present work should therefore appeal to the large public which takes an interest in rainfall, and as some 5000 observers read their gauges daily it will be realised how large that public is. Almost every observer would benefit by a perusal of this work, where he will find a discussion of the problems which he himself is assisting to solve. He will find an account of the various types of gauge, and that some, still in use and still sold by instrument makers, are untrustworthy. He will find the exposure of gauges discussed, and he may improve that of his own. He will learn how the data he supplies are used, and find maps illustrating various types of rain, some almost wholly influenced by orographical features, some by the passage of depressions, and others due to thunderstorms.

The discussion of seasonal variation and annual fluctuation will be read with much interest at the present time. Numerous maps are a great feature of the book, and are most instructive; any one who thinks that his own gauge is worth keeping should study the map of the thunderstorm rain in London on June 16, 1917, and note that there was no rain at the Oval, more than 4½ in. at Kensington, while one end of the Serpentine received less than 1 in. and the other more than 3 in.

The rain over the British Isles seems to fall into a watertight compartment; it is perhaps captious to complain that a book on our own rainfall does not discuss the rainfall of the Continent, but it would be of much interest to know how our rainfall links up with that on the other side of the Channel. Possibly the very excellence of the work of the British Rainfall Organization under Dr. Symons, Dr. Mill, and Mr. Salter himself, has made our own information so adequate that it cannot be compared in full detail with that of neighbouring countries.

There are one or two slips; for example, " right hand rear section " on page 179 should be " right hand front section." The diagram in Fig. 2 is not sufficiently explained to be intelligible to those readers who are not already familiar with the theories of Prof. Bjerknes. The glossary at the end is not very full: we look in vain, for example, for orographical rain and for convection. The book fills a gap in meteorological literature, and the concluding chapter on the economic application of rainfall data is an indication of how widely it should be studied, not only by meteorologists, but also by those outside their ranks.

(2) " Etudes élémentaires de Météorologie pratique " describes the ideal arrangement of stations for a meteorological service, the instruments used, including captive balloons, pilot balloons, and aeroplanes, and the general procedure of such stations. Part 2 is devoted to problems of pressure and wind, and part 3 discusses forecasting. Squalls and thunderstorms come in for full treatment, and also the sudden clearings of the sky, " éclaircies "; the author's experience as chief of the meteorological service of the Armies of the Centre probably led him to study this phenomenon, so important for aviation and hitherto much neglected. The author advocates numerous observation posts, so that a line squall, for instance, may not pass unnoticed between the regular stations of the service. If such a system had been adopted in this country during the war much serious damage might have been avoided at aerodromes in the South of England. The work does not pretend to be a meteorological handbook, but it is valuable for those engaged in official meteorological work, and it discusses interesting points, some of which may still be rather controversial. The chief fault of the work, if fault it be, is that it is unnecessarily full, which would have made an index all the more useful.

(3) Mr. Stenhouse's little book is intended for school students and for the general reader. The subject, including something of dynamic meteorology, is shortly and clearly explained. But there are a number of inaccuracies which ought to be corrected if the work runs into further editions. The coldest time of day is not a little after midnight but a little before sunrise; strato-cumulus is scarcely a combination of stratus and cumulus, nor is cumulus the typical cloud of the middle layer. Alto-cumulus is not even mentioned; and the distinction between cloud sheets and clouds of convection is not brought out. There are some good photographs, but they have not been well selected; snow and frost scenes do not teach anything in particular, and a more typical selection of cloud forms should have been given; the clouds in Plate VI., though given as cumulus, are nothing of the kind; the top picture in Plate VII. has been inverted. The diagrams of sections across weather maps make a misleading use of the term pressure-gradient. In spite of faults, however, the book forms an attractive introduction to meteorology for beginners.

(4) Unfortunately this cannot be said for Mr. Redway's " Handbook of Meteorology," which contains many inaccurate statements. Hydrogen, on account of its lightness, is stated to be thrown off into space by the rapid movement of the earth; air currents " are deflected by the rotation of the earth on its axis easterly in tropical latitudes, and westward beyond the tropics "; the isothermal layer separates the stratosphere and the troposphere; the stratosphere is stated to be radioactive, indicating the presence of electrified dust particles, and the reason why cloud particles remain suspended is stated to be unknown, and electrification is suggested as a possible explanation; these are only a few of the surprising statements to be found in this work.

C. J. P. CAVE.

Freshwater Ciliate Infusoria and Heliozoa.

(1) *Etudes sur les Infusoires d'Eau douce.* By Dr. E. Penard. Pp. 331. (Genève: Georg et Cie, 1922.)

(2) *The British Freshwater Rhizopoda and Heliozoa.* By J. Cash and G. H. Wailes. Assisted by J. Hopkinson. Vol. 5. *Heliozoa.* By G. H. Wailes. Pp. vi+72+11 plates. (London: for the Ray Society, 1921.)

(1) THERE is probably no large sheet of fresh water that has been so thoroughly investigated, so far as its fauna of protozoa is concerned, as the Lake of Geneva. Forel, Jean Roux, Penard, and others have shown its richness in variety of form, in the number of species, in cases of parasitism, and in adaptations to other special habits of life. They have set an example which we might well follow in regard to our English lakes, about which we still know so little.

Dr. Penard has already published massive volumes on the Rhizopoda, the Heliozoa, and the Acinetaria of the lake and neighbouring waters, and the present volume on the ciliate Infusoria, not restricted in this case to protozoa of the immediate locality, is no less imposing than the others.

Dr. Penard's work will doubtless meet with a great deal of severe criticism, because his histological methods are primitive and inefficient, his illustrations badly drawn and abominably reproduced, and the arrangement of the text is most inconvenient for the reader. But he disarms criticism, to some extent, as regards the first defect by his frank admission that all his observations have been made on the living organisms, and that only in certain cases has he used some *intra vitam* stains for special purposes. It is a grievous pity, however, that with such interesting material passing through his hands he has not been able to employ an artist to provide at least a few illustrations of the same delicacy and accuracy as those to be found in the works of Jean Roux. There is not a single one of the three hundred figures that can be said to be a good picture of a living infusorian. They are all crude and inaccurate diagrams.

But these serious defects must not be allowed to obscure the fact that there are recorded in this volume many very interesting and important observations on the natural history of these protozoa. The detailed account, for example, of the explosion of the large trichocysts of *Microthorax haliodiscus*, the description of the conjugation and gemmation of the new Heterotrich *Strombilidium gyrans*, the discovery of the formation of small copulation buds in Cothurnia, and many other records of the author's observations are really valuable contributions to knowledge, and suggest at any rate interesting lines of research for some one who can use more modern methods of technique.

Dr. Penard proposes to add to our lists the names of several new genera and many new species; but it seems very doubtful if these new genera and species can be established until a better and more trustworthy account of the nuclei and other details of structure can be provided. Any one who has had experience of investigations of these active minute organisms must be aware of the uncertainty of observations on the form and structure of the meganuclei that are made when the animals are still living. Such observations must be confirmed and extended by a study of properly fixed and stained preparations before they can be regarded as trustworthy. More particularly is this the case with the micronuclei, which are usually quite invisible during life and require the best technical methods for their complete elucidation; and we may note, in this connection, that the author does not mention either the sixteen micronuclei of *Bursaria truncatella* or the single but remarkably conspicuous micronucleus of *Spirochona gemmipara*.

In a group of animals such as the Ciliata, which possess so few trustworthy characters for systematic work and vary so much as regards these characters according to environmental conditions, the systematist should not be satisfied with his description of new species until every important character that can be seen by the ordinary methods of research has been seen and described. If microscopists pass from the description of one species of Ciliata to that of another before the nuclear structures of the first have been determined, as Dr. Penard has done, our literature, already overburdened with unnecessary specific names, will soon become most hopelessly perplexing and cumbersome.

Dr. Penard's work will be useful for reference, and perhaps suggestive of lines for further investigations by other methods of research, but it cannot be regarded as one that excites great confidence.

(2) The new volume on the freshwater Heliozoa of the British Isles published by the Ray Society gives a record of genera and the species that have been found by microscopists in this country who have been interested in the group, but it does not do justice either in text or plates to the important morphological features or to the beauty of form that these remarkably interesting protozoa possess.

It is very disappointing that in this monograph the general account of the structure and reproduction of the Heliozoa is so incomplete. For example, in the very slight treatment of the reproduction of Actinophrys and Actinosphærium there is no reference to the works of Schaudinn or R. Hertwig. It seems extraordinary also that those who are responsible for the publications of the Ray Society have no better methods to suggest to the young microscopist for the preservation of these delicate organisms than 5 per cent. carbolic acid, formalin, and methylated spirit, and that no methods at all are given for staining preserved specimens to bring out more clearly the structure of the nuclei and other minute details.

The purely systematic part of the work is more satisfactory, and the microscopist will find a short but clear description of all the species that have been recorded in this country with references to many of the more important papers in the literature of the subject. Of the eighteen text-figures only two seem to be original, the others being either reproductions of the coarse and lifeless illustrations in Penard's monograph or taken from other authors. Figures such as these, in which the detailed structure is not clearly or accurately shown, do not incite to careful and patient study, although they may assist to some extent in the identification of species. The illustrations in the plates also, with a few exceptions, are far below the standard we might reasonably expect in the publications of the Ray Society. They do not represent these beautiful little organisms as spherical in shape with radiating pseudopodia on the whole circumference, but rather as flat discs with the pseudopodia in one plane.

Another fault which seems to be unpardonable in a work of this kind is the failure to give any description or descriptive lettering of the figures to assist the reader. In such a figure as that on p. 44, for example, it is impossible to determine which of the several circles in the endoplasm of Pompholyxophrys is the nucleus and what the other things are supposed to represent. And again, in the illustrations of *Actinophrys sol* on Plates 67 and 72 there is no explanation of the different forms of the body and its pseudopodia that are represented. A few lines on the opposite page giving the reason why six different drawings of this one species are shown on the first of these two plates would have added immensely to the value and interest of the account of the species.

S. J. H.

Our Bookshelf.

Organic Syntheses: An Annual Publication of Satisfactory Methods for the Preparation of Organic Chemicals. Vol. 1. Pp. viii+84. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1921.) 8*s.* 6*d.* net.

IN preparing materials for use in research work in organic chemistry, much difficulty is experienced and time wasted because adequate directions are not available. Moreover, the methods finally adopted are not often published, so that the work involved in discovering how to make the preparation successfully is lost, and may be repeated indefinitely in different laboratories. The present volume is the first annual instalment of a record of methods of proved merit, given in sufficient detail to ensure easy repetition; the methods given have been tested by being carried out from the instructions in a different laboratory from that in which these were drafted. The substances dealt with in the first volume are alkyl bromides, allyl alcohol, benzinesulphonic chloride, benzil, benzilic acid, benzoin, α-bromonaphthalene, *p*-bromophenol, diacetone alcohol, furfurol, mesityl oxide, methylene iodide, methylhexyl carbinol, oxalic acid, thiophenol, trimethylamine, and trimethylamine hydrochloride. In future volumes it is hoped to include preparations worked out in other countries and tested by repetition in one of the four American laboratories which are responsible for the organisation of the scheme.

The preparation of materials such as these in quantities of from 200 to 2000 grams offers a unique opportunity for determining their physical constants by exact methods, *e.g.* a determination of freezing points to 0·01° by means of a standardised thermometer recording the temperature of 100 grams or more of purified material, instead of to about 1° by the use of a milligram of material in a capillary tube attached to a thermometer of unknown errors. This useful development of the work may perhaps be looked for in the later volumes of the series.

T. M. L.

Exploitation du Pétrole par Puits et Galeries. By Paul de Chambrier. Pp. 106. (Paris: Librarie Dunod, 1921.)

IN February 1921 a paper was read before the Institute of Petroleum Technologists on the working of petroleum by means of shafts and galleries, being an abstract from a pamphlet entitled "Exploitation du pétrole par puits et galeries," written by Prof. Paul de Chambrier. This pamphlet has recently come to hand, and it discusses at some length the methods employed more particularly at Péchelbronn, Alsace, in a bold attempt made to extract oil from certain horizons already exhausted by the drill.

The publication of the paper in this country created very considerable interest and even controversy at the time, and opinion was much divided as to the possibility of extending such methods to other fields. The pamphlet in its original form, however, makes most interesting reading, and there is no doubt that under certain specialised circumstances recourse may be had to this form of mining petroleum with decided probability of success. Such circumstances occur when (1) the producing bed has been drained so far as boring permits, (2) when there is an absence of gas under pressure, and (3) when the percentage of oil remaining in the bed is high enough to warrant the attempt being made. One may add a further condition, namely, that the bed does not lie at too great a depth from the surface.

The author contends that these methods allow the extraction of anything from two to five times the amount of oil obtainable by boring, and their ultimate employment, where possible, considerably enhances the economic value of the property. While these contentions may be quite justified commercially, it is open to doubt whether, from the scientific point of view, this practice will yield solutions to the fundamental questions of origin, migration and accumulation of petroleum, as indicated in the concluding paragraphs, but we recommend the careful perusal of the pamphlet before adverse criticism of this new departure be indulged in by either academic or technical expert.

H. B. MILNER.

The Chemistry of the Garden: A Primer for Amateurs and Young Gardeners. By H. H. Cousins. Macmillan's Primers. Revised Edition. Pp. xxxi+147. (London: Macmillan and Co., Ltd., 1921.) 2*s.* net.

THE new edition of Mr. Cousins's well-known little book will be welcomed by all who are interested in their gardens. In spite of the vast number of gardening books and the fact that it was first written twenty-three years ago, this book still remains one of the most useful guides that can be put into the hands of the amateur. Horticultural research does not move very quickly, and there has been less necessity for recasting than if the book had dealt with agriculture. Fuller investigation would no doubt cause modification in some of the recommendations made, but until it has been carried out the advice stands as the safest that can be given at present. Above all, its basis is sound. "I appeal," says the author, "to the gardeners of England to place themselves in line with the only true and sound method known to science, and the only safe and sure means to progress and discovery—experiment."

A Course of Practical Physiology for Agricultural Students. By J. Hammond and E. T. Halnan. Pp. 106. (Cambridge: At the University Press, 1920.) Price 4*s.* 6*d.* net.

THIS small book, which is not illustrated, contains exercises mainly in elementary histology for second-year students taking the course in agriculture at the University of Cambridge. Space is afforded for notes and drawings. The book will save time and labour for both student and teacher without disadvantage, as it does not pose as a text-book.

Letters to the Editor.

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

Atmospheric Refraction.

I perceive on further consideration that my suggestion (Nature, January 5, p. 8) of a spherical wave-front in place of a plane one to account for the discrepancy between the coefficient of terrestrial refraction as derived by Dr. Hunter from Mr. Mallock's proposition and the coefficient deduced from trigonometric levelling operations under ordinary conditions is inapplicable, for the reason that in practice we have to deal, not with a single point-source of light, but with an assemblage of point-sources the wave-front from which is sensibly plane.

There must, therefore, be some other explanation for the disagreement between the two values of the coefficient. I find on examining Dr. Hunter's figures (Nature, August 11, 1921, p. 745) that the almost exact two-to-one ratio between the values, which was suggestive of a simple geometrical explanation, is illusory owing to an unfortunate slip of Dr. Hunter in confusing sea miles with statute miles. The earth's radius in sea miles is not 3960, but 3437, and the resulting value of k from Mr. Mallock's proposition is not 0·133, as Dr. Hunter states, but 0·116. Using the Continental definition of k, this gives $k=0{\cdot}232$, which agrees with the value found by Jordan's formula (quoted in my former letter) for isothermal conditions at 0° C. As to the remaining discrepancy between 0·116 or 0·232 and the values of k (on the two definitions of it) which are usually found to hold in practice, it is clear both from Comdr. Baker's letter (Nature, January 5, p. 9) and from Jordan's formula that this is readily accounted for by temperature considerations. It is only under isothermal conditions, such as seldom or never occur in practice, that Mr. Mallock's result can be even approximately true; it was evidently incorrect to consider, as Mr. Mallock did in his reply to Dr. Hunter, that temperature effects could produce merely a difference in the result of 1 or 2 per cent. per 1000 ft. The mistake of assigning an insignificant part to temperature considerations is one which is very easily fallen into by any one who first considers the isothermal condition with its accompanying relation between density and pressure, because of the small effect which the existence of a temperature-gradient has on the rate of decrement of pressure as distinguished from density.

The great interest of Mr. Mallock's demonstration lies in its deriving the refractional radius under certain conditions in a very simple and elegant manner from the velocities of light in air and *in vacuo* and the height of the homogeneous atmosphere. What has led to some confusion is the omission from the enunciation of the proposition of the qualification that it holds true only for isothermal conditions and for air at 0° C.

Putting p for pressure, ρ for density, and h for height, we may take the refractional radius as depending only on dp/dh, as Mr. Mallock does, so long as we keep to isothermal conditions. But once we depart from these conditions, as is inevitably the case in practice, we must take it as depending on $d\rho/dh$, which no longer corresponds to dp/dh. We can, however, extend the simplicity of Mr. Mallock's reasoning to the condition of a linear temperature-gradient provided we replace the height of the homogeneous atmosphere, $-pdh/dp$ (or "pressure height," as Prof. Everett preferred to call it in his "C.G.S. System of Units"), by the "density height," $-\rho dh/d\rho$, which latter may be much greater than the "pressure height" under ordinary conditions.

Comdr. Baker lays great stress on the fact that the path of the refracted ray cannot be a circular arc unless the temperature-gradient is linear. This stress is justifiable, especially from the seaman's point of view of the problem; for the temperature-gradient in the air immediately over the sea is frequently far from linear, and in navigation horizontal sights must always be taken fairly close to the surface of the sea; moreover, it will seldom happen that the most favourable time of day can be chosen for observations at sea.

The moral is that in navigation too much reliance should never be placed on the results of observations made on a single bearing whenever the accuracy of the tabular value of the dip has to be assumed. But the land-surveyor is much less limited by conditions than the seaman; he can generally keep his lines well above the ground by observing between points of considerable elevation, he can choose that time for his observations when refraction is least likely to be abnormal, and he can usually get an adequate check on his results for the elevation of a point by observing it from a number of others at different distances and comparing the results. As a matter of experience, it is found by surveyors in many countries that during the afternoon hours, when refraction is steadiest, the assumption that the temperature-gradient is linear and the path of a nearly horizontal ray consequently a circular arc is tolerably near to the truth, at any rate for lines which do not run very close to the ground for any considerable part of their length. This follows from the close concordance between the trigonometric levels obtainable for the same point from stations at very different distances, when the observations have been taken under proper conditions and worked out by the usual formulæ.

John Ball.

Survey of Egypt, Cairo, February 11.

Diffraction by Molecular Clusters and the Quantum Structure of Light.

The investigations on the molecular scattering of light now in progress under the writer's direction (regarding which previous communications have been published in Nature) have brought to light some very remarkable cases in which the observed facts are in sharp contradiction with the theories of light-scattering based upon Maxwell's electromagnetic equations. According to the Einstein-Smoluchowski formula for the scattering power of a fluid, viz.

$$\frac{\pi^2}{18}\frac{RT\beta}{N\lambda^4}(\mu^2-1)^2(\mu^2+2)^2,$$

the intensity of the diffracted beam should be proportional to the compressibility β of the fluid and should thus be very large near the critical temperature as the compressibility is there great. Experiments by Keesom and Kammerlingh Onnes have confirmed this result in the case of ethylene vapour over a range of a few degrees above the critical temperature. The scattering powers of liquid carbon di-oxide and vapour for a considerable range of temperatures below the critical point have been determined in the writer's laboratory by Mr. K. R. Ramanathan, who has discovered that the formula is approximately valid only for a range of a few degrees below the critical temperature, and then falls off much more rapidly than according to the formula. These observations are significant in view of the observation by the present Lord Rayleigh that the scattering power of saturated carbon di-oxide vapour at 21° C. is only 102 times that of the gas at atmospheric pressure, whereas according to the Einstein-Smoluchowski formula, it should have been 855 times as great.

The failure of the formula indicated above is especially surprising in view of its successes in other directions, namely, in the case of gases obeying Boyle's law, in the case of liquids under ordinary conditions, and, with certain restrictions, even in the case of solids. In attempting to find an explanation of the failure, at first sight one naturally seeks to find some flaw in Einstein's theory, or in the application of it, but the very successes of the formula in other cases would tend to discourage such an attempt. The formula was deduced by Einstein by applying Boltzmann's principle of entropy-probability in order to find the magnitude of the fluctuations of density of the fluid arising from thermal agitation and deducing the light-scattering due to these fluctuations by application of Maxwell's electromagnetic equations. It is clear that density fluctuations due to thermal agitation must occur; that their magnitude is proportional to the square root of the compressibility of the medium as contemplated in the theory may be confirmed independently by identifying the thermal energy of the molecules with the energy of sound-waves of all possible wave-lengths in an enclosed volume of the fluid and equating the energies. Further, the idea that the non-uniformity of the density of the medium is the factor determining light-scattering, at least according to the wave-theory, is confirmed by the very complete analysis of the problem given by the late Lord Rayleigh in one of his final papers (*Phil. Mag.*, Dec. 1918, p. 449). How, then, are we to escape the difficulty?

A very luminous suggestion made by Jeans in his "Dynamical Theory of Gases" (page 203) is here of great help. Jeans distinguishes between two kinds of clustering in fluid media, *mass-clustering* and *molecular-clustering*, and points out that they tend to become identical at the critical temperature. Einstein's theory is based on the idea that the fluctuations of density and the resulting scattering of light are both due to *mass-clustering*. If, however, we assume that it is *molecular-clustering* that is of importance and results in an increased scattering of light, it is easy to see that in the case of molecules such as carbon di-oxide, which are ordinarily non-associated, the clustering of molecules would only be appreciable near the critical temperature, and that at lower temperatures the clusters would rapidly break up and resolve themselves into single molecules. A double molecule would scatter four times as strongly as a single molecule, a triple molecule nine times as strongly, and so on, and if we assume that the energy-effects of separate molecules or groups are additive, and calculate the number of associated molecules from thermodynamic principles, it is easy to give the theory quantitative expression and explain the increased scattering near the critical point, and the rapid fall at lower temperatures.

But the fundamental difficulty remains, why the *mass-clustering* considered by Einstein does not, as it should, according to the classical wave-theory of light, give rise to an increased scattering of light?

To the present writer, at any rate, it appears that this contradiction of the electromagnetic theory by experience may have to be classed with its other known failures in the theory of photo-electricity and other modern fields of inquiry. We may, in fact, have to adopt the quantum theory of the structure of light as propagated in space (and not only when it is absorbed or emitted) in order to explain the facts of molecular diffraction. Fuller experimental data which are now being obtained in the writer's laboratory may pave the way towards the clearing up of this fundamental question.

C. V. RAMAN.

210 Bowbazar Street, Calcutta, March 2, 1922.

The Radiant Spectrum.

PROF. RAMAN in his reply of February 9 to my criticism of his first letter of September 1, does not refer to the fundamental difference of opinion between us. For it was the statement "the phenomenon is due to diffraction by the corneal corpuscles," to which I took exception, because I could not find in his letter, or in Brewster's paper, any evidence on which such a conclusion could be based.

With regard to the corneal corpuscles, Schafer writes in his "Essentials of Histology" (p. 363, edition 6), "Between the laminæ (of the cornea) lie flattened connective tissue corpuscles, which are branched and united by their processes into a continuous network; there is, of course, a corresponding network of cell spaces." Since, then, the corneal corpuscles lie within the substance of the cornea, their optical effect will depend on their opacity to light, or on the difference between their refractive index and that of their surroundings. Now if there was opacity, or a difference in refractive index, they should be visible under the microscope. But such is apparently not the case. Staining with hæmatoxylem or some other suitable reagent, is necessary in order that they may be visible, and therefore their opacity, or difference in R.I., must be slight. We conclude, therefore, that they will cause but slight diffraction in a ray of light passing through the cornea. In shape the cells themselves are *highly* irregular, and they average in man 20-30 μ in diameter. Their nuclei in man are roughly oval in shape, about 16 μ in diameter. In order that these structures should produce the type of diffraction pattern described by Prof. Raman, there should be two sets of them, nearly circular in outline, with diameters of 13 μ and 7 μ respectively. But a further point arises: Prof. Raman describes slight relative movements on the part of the diffraction pattern, which he compares with those which occur when a film of milk on glass is held in front of the eye. This movement, he states, ceases if the eyelids and eyeball be kept motionless for a short time. Could the corneal corpuscles undergo this movement lying as they do in lacunæ in the substance of the cornea? And even if they could, why should their motion cease when the lids and eyes are kept still?

Not only has no evidence been advanced by Prof. Raman in support of his statement that the corneal corpuscles are responsible for the diffraction phenomena, but also the shape, size, situation, and optical properties of these structures would appear to be antagonistic to the view.

With regard to the scattering of light by a prism, the following experiment will be found to demonstrate the effect. On the bed of a spectrometer are placed, base to apex, two glass prisms of equal dispersion, with optically good and clean surfaces (see Fig. 1).

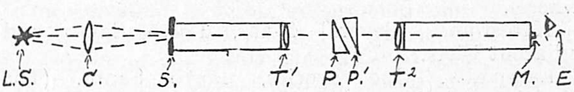

FIG. 1.—L.S., Arc or Pointolite. C., Condenser. S., Slit. T.[1], Lens of Collimator. P. & P.[1], Prisms. T.[2], Lens of Telescope. M., Metal Strip. E., Eye of Observer.

The telescope eye-piece having been removed, a

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narrow vertical strip of black sheet-metal or cardboard is fixed across the mouth of the telescope with plasticine, and the telescope is adjusted until the bright image of the slit is completely obstructed. On looking past the strip towards the prisms the observer will see parts of the latter brilliantly lit. By slightly shifting each prism in turn and watching for movement in the bright specks, those due to each prism are readily identified. H. HARTRIDGE.

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Land Snails of the Madeira Islands.

IN 1892 (*Journal of Conchology*, vol. vii. No. 1) the Rev. R. Boog Watson published a very interesting discussion of the Madeira snails, in which he raised many questions concerning their origin and history, which he did not attempt to answer. To-day, we are still groping for light, but I believe we may reach a number of conclusions which are not likely to prove erroneous.

(1.) It is not true that the numerous endemic snails of the islands have come "without trace of descent." They are quite clearly of Palæarctic origin, and their ancestors may be looked for in the rocks of Europe. Among the European Tertiary fossils, *Plebecula ramondi* Brong., from the Miocene of Germany, resembles the Madeira and Porto Santo Pleistocene fossil *P. bowditchiana*; *Pseudocampylaea insignis* Klein, from the Miocene of Würtemberg, resembles the great *P. lowei* of Porto Santo, but is not so large; two species of Craspedopoma, apparently allied to Madeira forms, are found in the Eocene of France. These fossils may be seen in the British Museum. In the absence of anatomical evidence, the relationships of these fossils must remain somewhat uncertain, but it is at least probable that their apparent affinity with the Madeira snails is not wholly deceptive.

(2.) Considering the diversity and strong peculiarities of most of the Madeira species, it is unlikely that their ancestors arrived later than the beginning of the Tertiary, and it is not improbable that at least part of the immigration dates from the Upper Cretaceous. This postulates a greater age for the islands than our present geological information can confirm. According to this view, the European fossils are presumably not the actual ancestors of the Madeira fauna, but derivatives from the same general stock.

(3.) A comparison between the snails of Madeira and the adjacent island of Porto Santo, which is easily visible from the coast of the larger island, shows that we have two very distinct faunæ, with very few species in common. More than this, various genera or subgenera are restricted to one of these islands, or specially characteristic of one. It is, I think, quite certain that during the whole long history of the snail fauna, Madeira and Porto Santo were never united. On the other hand, everything indicates that the three Desertas were during Tertiary time joined together and continuous, or nearly continuous, with Madeira. The following facts are illustrative:

Pseudocampylæa. Two species, Porto Santo only.

Cryptaxis. Three species, Madeira and Desertas (Leptaxis differs anatomically, as I shall show elsewhere).

Katostoma. Several forms, Porto Santo and adjacent islets.

Lampadia. One species, Porto Santo. (The Madeiran *membranacea* does not belong here.)

Idiomela. One species, Porto Santo.

Hispidella. One species, Madeira.

Lemniscia. One species, Porto Santo. (I am satisfied that the Madeira *calva* and *galeata* are not related.)

Actinella. Five species, Madeira and Desertas.

Hystricella. Seven species, Porto Santo and adjacent islets.

Geomitra. Seven species, Madeira and Desertas.

This list could be extended, but it is, I think, sufficient to indicate, not only that Madeira and Porto Santo were not united, but that they were never united with the mainland. The diversity of the genera and subgenera on the two islands might be expected as the result of accidental colonisation at very rare intervals, but could scarcely result from the breaking up of an originally homogeneous fauna. If we employ the aggregate genera Leptaxis and Geomitra (properly Ochthephila Beck, which is not preoccupied) without subdivision, the actual facts are obscured.

(4.) Nevertheless, we have to account for the occurrence of a certain number of identical species in the two islands, and the fact that some of the groups, such as Discula, are well represented on both islands, with closely allied species. The identical species were not introduced by man, as they occur fossil in the Pleistocene of Caniçal. As a general rule, when a group has representatives on both islands, it appears to be primarily or primitively a Porto Santo group. An apparent exception is Callina, with four Madeira species and one (*rotula*) in Porto Santo. The species *rotula* is very peculiar, and probably should not be associated with the others. How these various snails or their ancestors crossed the 23 miles from one island to the other is unknown. Some may have been carried by birds, possibly some may have come on floating pumice or other floating objects.[1] The reason for the apparent tendency of Porto Santo types to reach Madeira, rather than the reverse, may be found in the fact that the arid eastern end of Madeira is well suited to Porto Santo species, while Porto Santo is unsuited to the species from the moister uplands or coasts of the greater part of Madeira.

(5) The occurrence of well-defined species and subspecies on the islets around Porto Santo—some of them no larger than a large building—proves that no important oscillations of level have taken place in recent geological time. Very moderate alterations of level would submerge the islets, or unite them with the main island. The existence of these distinct forms on islets close to the main island also proves that the means of crossing the sea, whatever they are, operate at extremely infrequent intervals.

(6.) With regard to the species of the Madeiras which are actually identical with those of Europe, it must be said that the presumption is in nearly every case that they were introduced by man. It is possible, however, that some of the smaller ones were brought by "natural" means in geologically recent times, and highly probable that Balea was so brought to Porto Santo, on the feet of birds. Records of the occurrence of European species in the Pleistocene deposits of Madeira and Porto Santo all break down on critical examination.

That the islands are really "oceanic" is indicated by the total absence of indigenous mammals (except bats) and amphibians, and the general character of the invertebrate fauna and of the flora. The multitude of snails has seemed to suggest a former land connection, but I now believe that the snails themselves negative this view. T. D. A. COCKERELL.

University of Colorado, Boulder, March 2.

[1] Experiments should be made to determine whether it is even possible for snails protected by epiphragm or operculum, to pass alive through the alimentary canal of birds. Compare Wallis Kew, "The Dispersal of Shells," p. 45.

Optical Rotatory Dispersion.[1]

By PROF. T. M. LOWRY, F.R.S., and DR. P. C. AUSTIN.

1.—*Introduction.*

THE discovery of optical rotatory dispersion may be said to have preceded rather than followed the discovery of optical rotatory power, since it was the unequal rotation of the plane of polarisation of lights of different wave-lengths which gave rise to the sequence of beautiful colours which Arago described in 1811 as being produced by the interposition of quartz plates between a polariser and analyser set to extinction. These colours were shown by Biot in 1812 to be due to a rotation of the plane of polarisation which increased with the thickness of the quartz plate and with change of colour from red to violet. When, therefore, a beam of polarised light had passed through a quartz plate it was impossible any longer to extinguish all the colours simultaneously with any one setting of the analyser.

Two features of Biot's work deserve special attention. In the first place, all his measurements of optical rotatory power included observations of rotatory dispersion; the custom of observing the rotatory power of a substance for light of only one wave-length and thus recording a single point on a curve of unknown form is of comparatively recent origin, and marks a distinct retrogression from the more thorough methods of the earlier workers. The second characteristic was the exact quantitative character of the work. Although he had no source of monochromatic light except a ruby glass which gave a red light of average wave-length about 6530, Biot made a quantitative study of the influence of wave-length and of other physical conditions on rotatory power, expressing his results, whenever this was possible, by means of mathematical equations and diagrams.

Two of Biot's diagrams retain their interest even at the present time. The first shows, by means of a series of straight lines, the influence of dilution with water on the rotatory power of tartaric acid. This diagram enabled Biot to predict that dextro-tartaric acid when in the anhydrous glassy form would actually become lævorotatory at the red end of the spectrum at all temperatures below 23° C., a bold prediction that was verified experimentally ten years later.

The second of these diagrams was used by Biot to illustrate his discovery that the rotation of the plane of polarisation of light in quartz was inversely proportional to the square of the wave-lengths, using the figures determined by Newton for corresponding regions of the spectrum. In this diagram the thickness of quartz required to produce a given rotation was plotted against the square of the wave-length, and the result was a series of straight lines. Biot recognised that some of the readings differed from the calculated rotations by 2 or 3 per cent., but he was not in a position to decide whether these deviations were due to experimental errors or to some inaccuracy in his formula. Our own measurements have shown that Biot's diagram represents almost exactly the rotatory dispersion in quartz if the lines are drawn through a point a little to the right of the origin, and there can be little doubt that if more accurate methods of measurements had been available Biot's line of thought and method of representation would have led him almost inevitably to the simple formula for rotatory dispersion which has come into general use in recent years after the lapse of nearly a century.

2.—*Simple Rotatory Dispersion.*

As the accuracy of polarimetric work increased, the deviations from Biot's law of inverse squares became too important to be overlooked. The result was unfortunate, since those who destroyed the original formula had not got the skill to replace it by one that was more exact. For half a century, therefore, work on rotatory dispersion was limited to the occasional plotting of a curve of unknown form to represent the relationship between rotatory power and wave-length. As a natural result interest in the study of rotatory dispersion diminished, and (following the discovery of the Bunsen burner in 1866) the D line of the sodium flame acquired almost a monopoly as a source of light for the investigation of optical rotatory power.

During this period corrected formulæ were put forward by Boltzmann, who wrote $\alpha = A/\lambda^2 + B/\lambda^4$, and by Stefan, who wrote $\alpha = A + B/\lambda^2$; but these proved to be of little value, since they could not readily be made to fit the curves, and, being obviously empirical in character, could be used only as a means of interpolation between the experimental values.

This period of retrogression came to an end with Drude's application to optics of the electronic theory at the close of the nineteenth century. His theoretical investigations led to the enunciation of a somewhat elaborate formula for optical rotatory dispersion which (when approximate results only were required) could be used in the simplified form shown in the equation,

$$\alpha = \Sigma \frac{k_n}{\lambda^2 - \lambda_n^2},$$

where the dispersion-constants $\lambda_1^2, \lambda_2^2 \ldots \lambda_n^2$, could be deduced from the refractive power of the medium, while k_n represented a series of arbitrary constants depending on the rotatory power of the medium. A similar formula, which actually included the refractive index, was put forward to express the influence of wave-length on magnetic rotatory power. Drude tested his formula for optical rotatory dispersion in the case of quartz, whilst that for magnetic rotatory dispersion was tested in the case of carbon disulphide and of creosote; but for some years both formulæ remained almost barren so far as practical applications to measurements of rotatory dispersion were concerned. In particular, it may be noted (i) that a complete knowledge of the curve of refractive dispersion was required before either formula could be applied to measurements of rotatory dispersion, and (ii) that even the approximate formula for optical rotatory dispersion contained an indefinite number of arbitrary

[1] Abridged from the Bakerian Lecture delivered before the Royal Society on June 2, 1921.

constants. Drude himself did not apply his formula to a single member of the vast array of optically active liquids and solutions, which have been prepared and studied more especially from the time of Pasteur onwards, and he can, perhaps, scarcely be blamed for this omission, in view of the fact that the rotatory power of the great majority of these media had been determined for one wave-length only. It was therefore not until the problem of rotatory dispersion had been taken up afresh and new series of exact measurements had been accumulated that the unique merit of Drude's formula was established.

The results of these new tests were most striking. Fifty series of measurements of magnetic and optical rotatory dispersion were made and classified into groups with similar rotatory dispersion, in order to minimise individual errors of observation. It was then found (Lowry and Dickson, Trans. Chem. Soc., vol. 103, p. 1067, 1913) that the whole of these readings could be expressed within the limits of experimental error by using a single term of Drude's equation, involving only two arbitrary constants—namely, a "rotation-constant," k, and a "dispersion-constant," λ_0^2, as set out in the equation $\alpha = k/(\lambda^2 - \lambda_0^2)$.

The substances examined at this stage were nearly all compounds of simple structure—*e.g.* secondary alcohols of the aliphatic series; but the two methyl glucosides, each containing five asymmetric carbon atoms, were proved to obey the same simple law (Lowry and Abram, Trans. Faraday Soc., vol. 10, p. 112, 1914). A somewhat dramatic vindication of Drude's formula, in the case of compounds of much greater complexity, has, however, been provided by the more recent work of Prof. Rupe, of Basel, who published in 1915 (Ann. der Chem., vol. 409, p. 327, 1915) a series of measurements of the rotatory power for four different wave-lengths of some forty compounds of the terpene series. In order to determine the mathematical form of the dispersion-curves he plotted α against λ, log α against λ, log α against $1/\lambda$, α against $1/\lambda$, α against $1/\lambda^2$ (to test Biot's equation and Stefan's equation), and $\alpha\lambda^2$ against $1/\lambda^2$ (to test Boltzmann's equation); but in no case was there any indication of a linear relationship. The results obtained by plotting $1/\alpha$ against λ^2, in order to test the validity of the one-term Drude equation (Lowry and Abram, Trans. Chem. Soc., vol. 115, p. 300, 1919), are, however, most remarkable, since thirty-seven of the forty substances studied by Rupe give straight lines, and only three show any marked curvature. It is, moreover, noteworthy that two of these exceptional compounds agree in containing the group, $C:C(C_6H_5)_2$, although it is not clear why this group should be associated with the occurrence of abnormal optical properties.

Further work by Pickard and others has confirmed the fact that the rotatory dispersion of a vast range of organic compounds can be represented by the simple formula $\alpha = k/(\lambda^2 - \lambda_0^2)$, and that a satisfactory classification of optically active compounds can be made by distinguishing between "simple rotatory dispersion," where this law holds good within the limits of experimental error, and "complex rotatory dispersion," where marked deviations from the law are found.

3.—*Complex and Anomalous Rotatory Dispersion.*

Amongst the substances which do not obey the simple law of rotatory dispersion, tartaric acid and its derivatives have been conspicuous ever since Biot in 1837 directed attention to the peculiar behaviour of the acid in aqueous and in alcoholic solutions. The principal anomaly noted by Biot was the fact that the rotation, instead of increasing continuously with decreasing wave-length, rose to a maximum in the green, and then diminished again in the blue, indigo, and violet to values almost as low as those observed in the red region of the spectrum; but the extreme sensitiveness of the rotatory power of the acid to changes of temperature and concentration, as well as to the influence of solvents and of chemical agents, was in Biot's opinion at least as important an anomaly as the maximum in the curve of rotatory dispersion.

When, however, the quantitative basis for the study of rotatory dispersion had been destroyed, attention was no longer directed to the deviations from the law of inverse squares (which were then recognised as being universal), but to the qualitative peculiarities of the curves, which alone were regarded as justifying the use of the term "anomalous dispersion." The principal anomaly thus selected for special attention was the occurrence of a maximum; but a reversal of sign or a decrease of optical rotation with diminishing wave-length were sometimes included as anomalies of similar importance. The undue emphasis thus laid upon the qualitative anomalies has had some curious results; in particular, Winther not only adopted the view that the maximum is the sole criterion of anomalous rotatory dispersion, but actually insisted that this maximum must lie within the visible region of the spectrum. He therefore speaks of a dispersion-curve which "becomes normal in that the maximum passes into the ultra-violet," whilst a curve which cuts right across the axis is described as "normal with a maximum in the infra-red." A definition of anomalous dispersion which thus depends on the physiological properties of the eye, instead of on the physical properties of the medium, can scarcely be regarded as worthy of serious consideration, but it provides a suitable anticlimax to direct attention to the value of the more precise methods of treatment which prevailed when rotatory dispersion was first studied almost a century before.

A complete solution of the problem of anomalous rotatory dispersion has been found by returning to the mathematical methods of Biot and applying similar processes of analysis to curves plotted with the greater accuracy which modern physical apparatus has rendered possible. A series of dispersion-curves (Fig. 1) for aqueous solutions of tartaric acid of different concentrations will illustrate the typical forms of the curves that are encountered in studying the substances of this group.

These curves show clearly three principal anomalies —*inflexion*, *maximum*, and *reversal of sign*—appearing at various points on the experimental curves as the concentration of the solutions is altered.

Similar curves, but covering a wider range, are obtained when the esters of tartaric acid—*e.g.* methyl tartrate and ethyl tartrate (Fig. 2)—are examined as homogeneous liquids at different temperatures or in a series of different solvents (Lowry and Dickson, Trans. Chem. Soc., vol. 107, p. 1183, 1915; Lowry and Abram, *ibid.*, p. 1193).

Careful mathematical analysis has shown that all

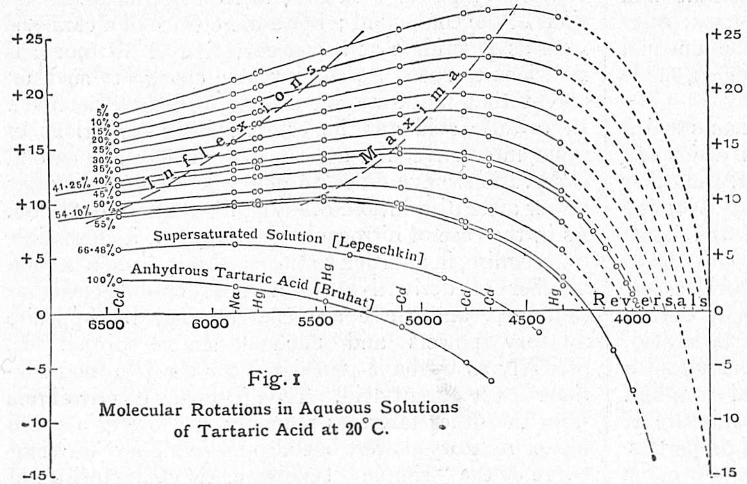

Fig. 1
Molecular Rotations in Aqueous Solutions of Tartaric Acid at 20° C.

these curves can be expressed by two terms of Drude's equation, of opposite sign and with unequal dispersion-constants—*e.g.*

$$\alpha = \frac{k_1}{\lambda^2 - \lambda_1^2} - \frac{k_2}{\lambda^2 - \lambda_2^2}.$$

The agreement is particularly good in the case of the esters. In the case of aqueous solutions of tartaric acid the ionisation of the acid appears to introduce an additional factor of complexity giving rise to small but systematic deviations from the values calculated by means of a two-term formula.

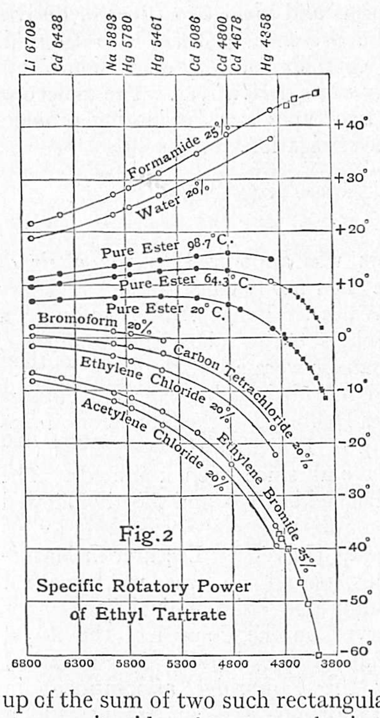

Fig. 2
Specific Rotatory Power of Ethyl Tartrate

In cases of "simple" rotatory dispersion Drude's formula postulates a linear relation between $1/\alpha$ and λ^2, but gives a rectangular hyperbola when α is plotted against λ^2. The corresponding dispersion-curves for methyl and ethyl tartrates are made up of the sum of two such rectangular hyperbolas, lying on opposite sides of a common horizontal asymptote, but working up to two different vertical asymptotes. These simple hyperbolas lie beyond the curves for solutions in formamide and in acetylene chloride, which are the highest and lowest of the series shown in Fig. 2, but every curve in this figure can be represented as a weighted mean of two such hyperbolas.

It should be noted that in this series of compounds the negative term always has a higher dispersion-constant than the positive term, so that the asymptote of the negative hyperbola is nearer to the visible region of the spectrum than that of the positive hyperbola. All the positive rotations are therefore drawn over towards the negative side as the wave-length diminishes, as in the top curve of Fig. 2, which shows a reversal of curvature on the extreme right. The curves in the upper part of Fig. 2 must therefore show, not merely one, but *all* of the features which are usually regarded as characteristic of anomalous rotatory dispersion—namely, (i) an inflexion, (ii) a maximum, (iii) a diminution of rotatory power with decreasing wave-length, (iv) a reversal of sign.

On the other hand, the curves at the bottom of Fig. 2 are negative throughout, since the positive term is always smaller than the negative term of the equation. There is therefore no inflexion, maximum, or reversal of sign. The curves obtained by plotting α against λ^2 are, however, not rectangular hyperbolas, but the weighted means of two hyperbolas, and require two terms of the Drude formula to represent them. Although, therefore, these curves are not anomalous, they are not "simple," and must be classed with the anomalous curves as "complex."

It should be noted that a small alteration in the numerical values of the constants of the equation for a complex curve may suffice to introduce the whole range of anomalies, or alternatively to remove them, whereas, to render a complex curve simple, one of the two terms in the complex equation must be made to disappear altogether. The difference between simple and complex dispersion is therefore probably of more significance than that between normal and anomalous dispersion, in spite of the more picturesque character of the latter contrast.

4.—*The Origin of Anomalous Rotatory Dispersion.*

It has been shown above that the curves of rotatory dispersion of organic compounds may be of three types—(i) simple, as in the case of the vast majority of the alcohols, acids, sugars, terpenes, etc., to which reference has already been made; (ii) complex, but without anomalies, as in the case of the tartaric esters when dissolved in solvents such as acetylene tetrachloride; (iii) anomalous, as in the case of tartaric acid and its esters. What, then, is the origin of the complexities seen in classes (ii) and (iii)? Mathematically they depend on the same fundamental factor—namely, the introduction into the equation of rotatory dispersion of a second term of opposite sign, which is absent in class (i). From the chemical point of view it is difficult to avoid the conclusion that the complexities expressed by the two-term formula are due to the presence in these liquids of two kinds of optically active molecules, differing in sign and in dispersive power, but each characterised by a simple rotatory dispersion corresponding with one term of the equation.

This suggestion is far from new. Biot himself, as long ago as 1836, produced an artificial anomaly when he attempted to compensate the optical rotatory power of lævorotatory turpentine by means of a column of dextrorotatory oil of lemon. Similar results were obtained with artificial mixtures of turpentine and camphor; and so long ago as 1858 Arndtsen, after establishing by his own measurements the unequal dispersive power of optically active compounds, made the following suggestions:—

"If one should imagine two active substances which do not act chemically upon one another, of which one turns the plane of polarisation to the right, the other to the left, and, in addition, that the rotation of the first increases (with the refrangibility of the light) more rapidly than that of the other, it is clear that, on mixing these substances in certain proportions, one would have combinations which would show optical phenomena precisely similar to those of tartaric acid, as M. Biot has already proved by his researches on different mixtures of turpentine and natural camphor. One could then regard tartaric acid as a mixture of two substances differing only in their optical properties, of which one would have a negative, and the other a positive, rotatory power, and of which the rotations would vary in different proportions with the refrangibility of the light."

This suggestion, made more than sixty years ago, can now be supported by two additional lines of argument: (i) the mathematical evidence that the rotatory dispersion of these substances is in fact the sum of two simple rotations—*e.g.* as expressed graphically by the fact that the complex curves obtained by plotting α against λ^2 are merely the weighted mean of two rectangular hyperbolas; (ii) the chemical evidence that mixtures of isomers do in fact exist, which fulfil the conditions laid down by Arndtsen. Of these optically active "dynamic isomerides" nitrocamphor was one of the earliest examples to be studied, and it is still one of the best illustrations that can be given of this group of phenomena.

The existence of two forms of nitrocamphor was proved by the discovery of mutarotation—*i.e.* change of rotatory power with time in freshly prepared solutions of the compound; but a mere trace of a catalyst, such as piperidine at a concentration of M/10,000, is sufficient to speed up the isomeric change to such an extent that mutarotation can no longer be detected. In tartaric acid and its esters similar conditions of rapid interconversion appear to prevail, since careful observations have failed to detect any lag of rotatory power after dissolution, dilution, distillation, or fusion. As in the case of nitrocamphor, however, it is possible to recognise, in addition to the usual mixtures, a certain number of derivatives of a fixed or homogeneous character, and these are characterised by opposite rotatory powers and unequal simple dispersions, precisely as we have postulated for the two modifications of the parent acid. Thus (i) tartar emetic differs from the other tartrates not only in showing a much higher rotatory power, but also in giving a dispersion-curve of the "simple" type which is characteristic of the vast majority of optically active organic compounds; (ii) on adding an excess of alkali to tartar emetic a lævorotatory derivative is produced, but this also exhibits simple rotatory dispersion; (iii) boric acid also possesses the power of fixing tartaric acid in a dextrorotatory form with simple rotatory dispersion.

In view of these observations it is difficult to resist the conclusion that tartaric acid, like nitrocamphor, can exist in two forms and yield two types of derivatives, and that the presence of these two types is responsible for the complex rotatory dispersion of the acid and of so many of its derivatives. The molecular structure of these two types is a fascinating problem which still awaits investigation.

Obituary.

DR. G. B. MATHEWS, F.R.S.

BRIEFLY recorded in NATURE a fortnight ago, the death of Dr. George Ballard Mathews occurred in a Liverpool nursing home on March 19.

Born in London (February 23, 1861), of a Herefordshire family, Mathews' versatile intellect showed itself during his schoolboy days at Ludlow Grammar School, where the then head master instructed his boys in Hebrew and Sanscrit as well as in Greek and Latin. After a year at University College, London, where he studied geometry under Henrici, and of which body he later became a fellow, he entered St. John's College, Cambridge, which offered him the senior scholarship of his year either in mathematics or classics. Carrying out his intention of reading for the Mathematical Tripos he became a private pupil of Mr. W. H. Besant of St. John's. The keen competition for leading places in the Tripos of this period had brought fame to Mr. E. J. Routh as a coach and all the abler candidates went to Routh as a matter of course, for Routh had a long series of senior wranglers to his credit. However, Mathews' name was read out first in the list of 1883, this being the only break in a succession of about thirty consecutive seniors trained by Routh.

In 1884 Mathews was appointed to the chair of mathematics in the then newly-constituted University College of North Wales at Bangor, his election to a fellowship at St. John's taking place the same year. His colleagues at Bangor were all of the same generation as himself and included such men as Professors Andrew Gray, James Dobbie, and the late Henry Jones under the leadership of Principal Harry Reichel (the last three named have all since been knighted). The Bangor chair was resigned in 1896, and shortly followed by Mathews' election into the Royal Society and by his return to Cambridge as University Lecturer in Mathematics. During this period he was mathematical secretary of the Cambridge Philosophical Society for a time and also served on the Council of the Royal Society and on that of the London Mathematical Society. Resigning the Cambridge appointment in 1906 he returned to Bangor and, since 1911, held a special lectureship in the North Wales University College. The honorary degree of LL.D. was conferred by Glasgow University in 1915, and he again acted as professor of mathematics in Bangor during the two College sessions 1917–19. Dr. Mathews himself attributed the distressing series of illnesses which clouded the last three years of his life, and ended it, to the enforced system of rationing during the latter part of the war.

While thoroughly familiar with all branches of pure mathematics, Mathews' main interests were in the theory of numbers and projective geometry. The theory of numbers which, in its widest sense, is the theory of discrete as opposed to continuous magnitude, has passed through four well-defined stages of development. First there came the Diophantine analysis proper, of which the greatest exponents, after Diophantos among the ancient Greeks, were Fermat and Euler. In this the general problem is to determine all the solutions in rational numbers of a system of m ($\angle n$) algebraic equations.

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

Next came the discovery of the law of quadratic reciprocity which rendered possible a discussion of quadratic arithmetical forms, so ably expounded by Gauss in the "Disquisitiones Arithmeticæ." Such writers as Lejeune-Dirichlet, Eisenstein, and Stephen Smith added much to what Gauss had done, and a scholarly introduction to the whole theory was given by Mathews in his "Theory of Numbers" of 1892. A problem which arises in the theory of quadratic forms (the determination of the class-number) was the forerunner of the analytical theory which is intimately bound up with certain transcendental functions of a complex variable. It had little attraction for Mathews (though his book contains an introduction to it), but has recently received much attention from Prof. E. Landau, Prof. G. H. Hardy, and the late S. Ramanujan. The fourth stage was marked by Dedekind's discovery of his theory of ideal numbers, which restore completely to a system of algebraic numbers certain factorisation properties of ordinary integers that appear at first to be lost. Taking numbers of the type $a+b\sqrt{-5}$, where a, b are ordinary integers, a threefold factorisation of 21 is possible, viz.:

$$21=3\times7=(4+\sqrt{-5})(4-\sqrt{-5})$$
$$=(1+2\sqrt{-5})(1-2\sqrt{-5}),$$

whereas none of the factors $3, 4+\sqrt{-5}$, etc., is decomposable into two factors $(a+b\sqrt{-5})(c+d\sqrt{-5})$.

Mathews' was probably the first mind in England to realise the far-reaching effect of Dedekind's discovery, two papers by him on the subject appearing in the London Mathematical Society's Proceedings of 1892. The tract "Algebraic Equations" on a kindred topic, written fifteen years later, contains a masterly exposition of Galois' theory, completed by Jordan and others, showing how the different types of irrationality which can be defined by an algebraic equation are associated with different types of group.

Written in collaboration with Prof. Andrew Gray, the "Treatise on Bessel Functions," concerned mainly with physical applications, is still a standard work. The "Projective Geometry" (1914), inspired by Henrici's lectures in London many years before, contains two unusual features: first, an exposition of the logical groundwork of the subject, and secondly, an account of Staudt's theory of complex elements (whereby a real involution defines a complex point or line). He also brought out a new edition of R. F. Scott's "Determinants" (1904), and contributed articles on *Number* and *Universal Algebra* to the 1910 edition of the "Encyclopædia Britannica."

Most of Mathews' mathematical papers appeared in the London Mathematical Society's Proceedings or in the "Messenger of Mathematics." A few of them are geometrical, and nearly all the rest have an arithmetical bearing. Pride of place, perhaps, should be given to a four-page note of 1897, in which he explained a method of reducing multiple partitions to a single partition. Several papers were written on the complex multiplication of elliptic functions, a subject which had a singular fascination for Mathews. The publication of a manuscript on the lemniscate functions has been delayed by the war and his subsequent illness.

Ever since the mid-eighties NATURE has published frequent reviews and articles from Mathews' pen. These articles, most of which appeared over the initials "G. B. M.," were always written in a careful and scholarly style; they contained his considered opinion on the book or point concerned. In conversation with the present writer he once expressed the opinion that some of his best work had appeared in NATURE reviews.

A man of simple tastes and naturally retiring by disposition, Mathews expressed sound judgment on both men and affairs. Some of his views, perhaps, were those of an idealist, and hardly feasible in the domain of practical politics. His capacity for maturely grasping everything with which his mind came into contact made him unique in the experience of his friends. Only one or two sides of so versatile a man's brilliant intellect really appealed to most people. When he was appointed professor of mathematics at Bangor, at the age of twenty-three, it was manifest that he could equally well fill four or more chairs in the college. During recent years he spent much time in reading and translating Arabic: he was also a competent musician. W. E. H. B.

DR. J. T. MERZ.

DR. JOHN THEODORE MERZ, whose death on March 21, in his eighty-second year, was announced last week, was a son of Dr. Philip Merz, headmaster of the Chorlton High School, one of the pioneer institutions of higher education in Manchester. He was an acknowledged authority upon industrial chemistry and took a leading part in the industrial development of electricity supply, being one of the founders of the Newcastle-upon-Tyne Electric Supply Company. By the use of his great scientific and practical knowledge, he rendered invaluable service to the industrial community of Tyneside and the counties of Northumberland and Durham.

Dr. Merz will, however, be most widely remembered on account of literary activities, which go so far back as 1864, when he wrote a paper, which was published in Germany, on Francis Bacon, and another on Kant. For a long time the work by which he was best known was a small but much appreciated volume on Leibniz, contributed in 1884 to Blackwood's "Philosophical Classics for English Readers." A German translation of this appeared in 1886. These publications, however, were mere preliminaries to that which he had planned as the great work of his life, "The History of European Thought in the Nineteenth Century." The first volume of this was published in 1896, the fourth and last at the end of 1914. From the first the wide-ranging history, learned but never dry, was a literary success, receiving praise from all sides and from thinkers of all schools. The impartiality with which the author treated the contributions made to thought by England, France, and Germany respectively was universally recognised. This work he was able to complete so far as scientific and philosophical thought are concerned. A third part to be devoted to the less systematic thought that has found its expression in *belles lettres* was projected, and was to consist, like the two parts on scientific and philosophical thought, of two volumes; but this Dr. Merz finally decided, though he had collected much material, must be left for some successor.

Dr. Merz's labours, however, did not by any means cease. At the end of 1915 he published a very interesting essay on Religion and Science, in which he showed that the certainty of science within its limits depends on its method of abstraction. A view of things "all together," in which the mind, without which the external world cannot be known, is restored as part of the total system of reality, leads to recognition of the religious attitude as a mode of comprehending the universe, including man. Philosophy mediates between science and religion, explaining the validity in its own manner of each mode of viewing things.

In a like essay, "Fragment on the Human Mind" (1919), Dr. Merz showed his freedom from some prejudices of that reaction in nineteenth-century English thought which had gone to Germany for a more spiritual doctrine than the native philosophy seemed to result in. Knowing and appreciating the rule of Kant and Hegel and their successors, in the end he found in the psychological method of Locke, Berkeley, and Hume the most valid, as well as the most accessible way to show the fallacies of the "mechanical Philosophy" when regarded, not simply as the most powerful instrument of scientific thought, but as revealing the ultimate nature of the universe. To give us a suggestion that reality is spiritual, Locke's "plain historical way," namely, the method of introspection, remains sufficient.

Colonel Sir Henry Thuillier, K.C.I.E.

The late Sir Henry Thuillier, who died on March 4, was Surveyor-General of India from 1886 to 1895, and was distinguished as an able and tactful administrator. His name is so generally associated with administrative work, that his success as a geodetic observer in the earlier part of his career is apt to be overlooked.

Thuillier was commissioned in the Bengal Engineers in 1857, the year of the Mutiny, and he was appointed to the Great Trigonometrical Survey of India in 1859. In 1859–1861 he was one of the observers employed in carrying a chain of principal triangulation round the Punjab frontier along the line of the river Indus; this chain has been the fundamental base of all the later surveys, which have been extended during campaigns into Afghanistan, Waziristan, and Tirah.

In 1862 Thuillier was appointed to the eastern frontier of India, and for the next six years he had the difficult task of extending the principal triangulation eastwards from Calcutta to Burma. During the first half of the nineteenth century the geodetic triangulation had been carried across mountains and plains, deserts, fields and forests, and the observers had had to adapt their methods of observation to the varying types of country; but in Eastern Bengal Thuillier encountered a type of country that had not been met with before, and which was probably the most unsuitable of all types for triangulation. He had to carry chains of triangles over the deltaic swamps of the Ganges and Brahmaputra; the country was absolutely flat and overgrown with heavy jungle.

Thuillier had to cut glades through the jungle so as to render the several stations of his triangulation mutually visible from one another. The party suffered continually from malaria; the clearing of the glades was so laborious that their width had to be limited to a few feet. The exact line in which any particular glade had to be cut from one station to another was not known with sufficient accuracy to enable the men to clear the jungle in the correct direction, and numerous trial glades had to be cut in order to determine the true alignment. In one year on the Brahmaputra series of triangulation, Thuillier had to clear 700 miles of glade through dense jungle, and in the six years the total length of the clearance lines was nearly 4000 miles.

Sir Henry Thuillier had also considerable experience of surveying at high altitudes. He was trained in the famous Kashmir survey of Montgomerie and Godwin-Austen (1861), and from 1870 to 1873 he was in charge of the survey of the Kumaun Himalayas, including the glacial areas of Nanda Devi and Trisul. Many of his survey marks were above 20,000 feet.

Prof. J. A. Green.

We are grieved to hear of the sudden death, following upon an operation, of Prof. John Alfred Green, professor of education in Sheffield University. Many of us knew Prof. Green best in connection with the Educational Science Section of the British Association, of which he was for several years Recorder. He had the virtue we admire in a Tangye silent gas engine—converting all his energy into work and none into fuss—of a restrained enthusiasm, able to work in harness, but no less enthusiastic because he did not boil over into the vapid. Hence he was invaluable in the early days of the Educational Science Section, when many doubted whether there were, or could be, such a thing as educational science. But Prof. Green had visions and lived to realise them. He was secretary of the Committee on Mental and Physical Factors involved in Education, and the opening pages of the Report presented at Sheffield in 1910 make his attitude clear: "application of experimental methods to the investigation of mental phenomena" . . . "study of the persons to be educated and their attitude towards methods of instruction." If Section L still devotes a day annually to education and psychology, that is largely Prof. Green's doing. The work was carried further by him in *The Journal of Experimental Pedagogy*, which he edited. In that journal Prof. Green has left us a monument and a guidepost which may encourage us to go forward in the way which he was one of the first to tread.

H. R.

Current Topics and Events.

THE Board of Trade announces that, in connection with the Safeguarding of Industries Act, judgment has been given by the referee in arbitrations regarding the following articles. Against the name of the article is shown the decision of the referee, *i.e.* whether it has been properly or improperly included in, or excluded from, the lists of articles chargeable with duty under Part I. of the Act:

Article.	*Judgment.*
Calcium Carbide	Properly excluded.
R. Lactose	Improperly included.
Cream of Tartar, Tartaric Acid, Citric Acid	Improperly included.
Planimeters and Integrators (Planimeter type) . . .	Properly included.
Calculating Cylinders . . .	Properly included.
Mucic Acid	Properly included.

In two cases, viz. that of R. lactose and that of cream of tartar, tartaric acid, and citric acid, the decisions are against the Board of Trade, and those substances are accordingly withdrawn from the lists of dutiable articles as from March 25, which is the date of signature of the awards. The *Chemical Age* of March 25 announces that an inquiry which should have opened into a complaint that barium peroxide had been wrongly included in the list had been decided by agreement between the producers and consumers. It is quite clear from these results that sufficient care had not been exercised by the persons concerned in drawing up the list in the first case, and if the announcement in the *Observer* of March 26, to the effect that the Board of Trade were to recommend the repeal of the Act, is correct, it would appear that the difficulties of working such a measure had become too great to justify its further continuance.

AN exceptionally severe frost was experienced in most parts of England in the early morning of April 2, and the minimum temperatures reported to the Meteorological Office were in many places unprecedented for April. The temperature in the screen at Kew Observatory was 26°, which is the lowest April reading since observations commenced more than half a century ago. At South Farnborough, Hants, and at Benson, Oxon, the sheltered thermometer registered 21°. In consequence of the clear sky which prevailed the exposed thermometer fell generally about 10° below that in the screen, and at Shoeburyness the reading on the ground was 11°. At Greenwich Observatory the sheltered thermometer registered 25° and the terrestrial radiation temperature was 15°. The records at Greenwich, extending back to 1841, show only one instance of a lower temperature in the screen in April, the thermometer registering 23° on April 17 in 1847. There was a reading of 25° on April 1, 1859. Very heavy snowstorms were experienced in the south-western districts during the night of March 31 and on the following day, the ground being covered to a great depth. The storm was due to a disturbance moving from Cornwall across the English Channel. This storm area was followed by a region of fairly high barometric pressure which accompanied the cold snap.

THE Council of the Optical Society is arranging a programme of papers dealing with motor head lights, having reference more particularly to the optical problems involved. The question of "glare" or "dazzle," and the methods proposed for overcoming it will be considered alike from the point of view of the optician, the lamp manufacturer, and the road user. The meeting will be held at the Imperial College of Science and Technology, South Kensington, on May 11, and any one desiring to contribute to the discussion, to exhibit models, or to give experimental demonstrations is requested to communicate with the honorary secretary of the Society, Mr. F. F. S. Bryson, Glass Research Association, 50 Bedford Square, W.C.1.

THE *Times* announces that the Mount Everest expedition was to leave Darjeeling on March 26 for Tibet. Brig.-Gen. C. G. Bruce, chief of the expedition, was accompanied by Col. E. L. Strutt; Mr. G. L. Mallory, of last year's expedition; Dr. T. G. Longstaff; Maj. E. F. Norton; Dr. A. M. Wakefield; Mr. T. H. Somervell: Capt. J. Noel; Capt. G. Bruce; and Capt. E. J. Morris. Capt. G. Finch and Mr. C. G. Crawford remained behind to superintend the transport of the oxygen outfit upon which a great part of the success of the expedition depends. It will be noticed that the party is considerably larger than the one that made the successful reconnaissance last year. No trouble seems to have been experienced in enlisting porters among the hillmen. It is hoped that by April 6 the whole expedition will have assembled at Phari Dzong ready to set out and establish advanced bases in the Rongbuk and East Rongbuk valleys. A considerable time will be spent in training the porters in the use of ropes and ice axes and, in consequence, no delay is anticipated from the fact that the oxygen apparatus has not yet reached India.

FOR the purpose of carrying on the Ice Patrol Service provided for by the International Convention for the Safety of Life at Sea, the U.S. cutter *Seneca* has been detailed for duty off the Newfoundland Banks. According to the North Atlantic Meteorological Chart for April, this vessel was to go to sea in February 6 with orders to locate icefields and keep in touch with the drift of icebergs. About April 1, when the ice has moved well south, the U.S. cutters *Tampa* and *Modoc* will join the patrol, the three vessels continuing their work throughout the season of dangerous ice conditions. On getting in touch with the ice, the *Seneca* will report to the Hydrographic Office, New York, either direct or through any vessel within reach. Daily wireless messages will advise ships at sea. All messages will be sent in plain English. Masters of trans-Atlantic vessels are asked to report to the patrol vessels the location of icebergs or drift-ice and the temperature of the water every four hours between latitudes 39° N. and 48° N. and between longitudes 53° W. and 44° W. These data are required in order to ascertain the branches of the Labrador current.

A DEPARTMENTAL COMMITTEE has been appointed by the Minister of Agriculture and Fisheries "to inquire into the origin and circumstances of the recent outbreak of foot-and-mouth disease and into the policy and procedure which was pursued in dealing with the disease, and to report whether any alteration of the methods of administrative control hitherto adopted, or any amendment of the existing law, is necessary or desirable." The committee is constituted as follows: Capt. E. G. Pretyman (chairman), Mr. A. Batchelor, Mr. David Ferrie, Mr. F. W. Garnett, Mr. H. German, Mr. William Graham, Mr. Alfred Mansell, Sir G. Douglas Newton, Prof. J. Penberthy, and Mr. W. R. Smith. The secretary of the committee is Mr. S. A. Piggott, Ministry of Agriculture and Fisheries, 4 Whitehall Place, S.W.1, to whom all communications should be addressed.

THE British Rainfall Organization has removed its quarters from Camden Square, where its work has been carried on for more than half a century, to the Meteorological Office at South Kensington. For about three years the organization, which was formerly of a private nature, has been carried on as part of the official meteorological service of the country. It is thought that the general meteorological work will be greatly facilitated by being under the one roof in Exhibition Road, South Kensington. The Rainfall Organization was transferred from March 20. The absorption of the Meteorological Office in the Air Ministry has made it necessary for parts of the Office to be at the Air Ministry Offices in Kingsway. The office at South Kensington deals with climatology and instruments.

MR. ROBERT SARGEANT has retired from the Meteorological Office after rather more than 50 years' service. He entered the office in 1871 when it was controlled by a Committee of the Royal Society, at a time when ordinary weather forecasts, initiated by Admiral Fitzroy, had been discontinued. At that time weather reports were both received and published; they were used for the issue of storm warnings. Throughout the whole period of his service, Mr. Sargeant was engaged in the Daily Weather Report and Forecast Branch. He was also an Inspector of Meteorological Stations, and prior to his retirement had become Assistant Superintendent of the Forecast Branch. Mr. Sargeant's claim as a forecaster was based upon long experience and was chiefly associated with empirical rules; indeed, he is almost the last of a class which is being superseded by mathematicians and physicists who are working at the foundations of weather forecasting along strictly scientific lines.

THE number of journals entirely devoted to the study of earthquakes and volcanoes is small, and we welcome the publication of a new one, *Seismological Notes*, issued by the Imperial Earthquake Investigation Committee, Japan, and intended to contain preliminary reports on the Tokyo seismographical observations. To the first number Prof. Omori contributes two notes, one of which, on the great Chinese earthquake of December 16, 1920, contains reproductions of several Tokyo seismograms. He locates the origin in lat. 37° 5′ N., long. 106° 5′ E., a point close to several towns at which the shock was most disastrous, and between the centres of the great earthquakes of 1556 and 1561. The former of these earthquakes, by which more than 830,000 persons were killed, was probably the most disastrous of which we have any record.

THE third general meeting of the West Yorkshire Metallurgical Society, held in the City Museum, Leeds, on Saturday, April 1, took the form of a symposium of papers on the electric melting of metals; three original papers were read and discussed. The meeting was the last of a very successful winter session of this newly-formed metallurgical society. The membership, open to metallurgists, engineers, students, and others technically interested in the refining and working of metals, is steadily growing, and it is hoped that by next session the roll will contain a hundred members. The winter programme consists of meetings for the reading and discussion of papers in towns covered by the Society's activities, such as Leeds, Bradford, and Huddersfield. In addition to this and a summer programme comprising afternoon visits to works of interest to the members, the Society hopes to carry out suitably organised co-operative research through its members. The first president is Mr. T. E. Hull, and the hon. sec. is Mr. H. C. Dews, 17 St. John's Road, Huddersfield.

THE second annual report for 1921 of the Glass Research Association contains, in addition to the list of officers and members and its balance sheet, a statement of the problems already investigated and those under test. It appears that in addition to laboratories, now fully equipped, which the Association itself possesses at 50 Bedford Square, London, W.C.1, other institutions such as the National Physical Laboratory, the Department of Glass Technology, University of Sheffield, the British Refractories Research Association, and the Industrial Fatigue Research Board have all undertaken problems on behalf of the Association. Of the specific and definite results, one may refer to an investigation on the detection of cords in glass, the formation of "bloom" on lamp-blown glassware, the purification of mercury, the determination of the viscosity of a series of glasses over a limited range of (comparatively low) temperature, and the effect of the presence of chlorides and sulphates on the melting rate, working properties, and development of opalescence in lead glasses. On these subjects reports have appeared in the Bulletin of the Association. On the subject of glass-works practice, a new type of annealing lehr has been designed and erected, and a new furnace, an oil burner, and a cracking-off machine developed. References to other work and to research contemplated range over a wide field, but one of the subjects specially emphasised is that of glass refractory materials, and it is expected that co-operation with the British Refractories Research Association will carry forward investigations in this field speedily.

MESSRS. A. GALLENKAMP & Co., of Sun Street, E.C., have issued a catalogue of the latest forms of electrical resistance furnaces manufactured by them for various purposes. The heating element consists of a special alloy in the form of wire or strip, wound over a silica tube or muffle, and the furnaces are so constructed that the element may readily be removed by the user when burnt out, and replaced by a spare part. The maximum working temperature is 1000° C., and special types of furnace are made for the determination of carbon in steel, the estimation of ash in coal, the Lessing coking test for coal, and for organic combustions. The ordinary patterns are suited to such operations as the heat treatment of specimens of metals, the determination of the critical points of steel, and the checking of pyrometers against a standard. The power consumed by the furnaces when working at 1000° C. ranges from 400 watts for a tube 12 inches long and 1 inch diameter to 2300 watts for a muffle $14 \times 7 \times 4\frac{5}{8}$ inches. Details of accessories such as rheostats for controlling the temperature, ammeters, etc., are given, and the prices are also stated—a feature often absent from modern catalogues.

A NUMBER of reprints of communications made to the Edinburgh meeting of the British Association have been issued from the office of the Association in Burlington House, Piccadilly, W.1. We have received numbers 1-7 as follows: (1) Science and Ethics, by Dr. E. H. Griffiths, 9*d.*; (2) The Structure of Molecules, 9*d.*; (3) The Effects of the War on Credit, Currency, Finance, and Foreign Exchanges, 1*s.* 6*d.*; (4) Complex Stress Distributions in Engineering Materials, 3*s.* 6*d.*; (5) Charts and Pictures for Use in Schools, 1*s.*; (6) An International Auxiliary Language, 1*s.*; and (7) Report of the Conference of Delegates of Corresponding Societies, which contains Sir Richard Gregory's presidential address, "The Message of Science." It will be a great convenience to have these discussions and reports in pamphlet form, and it is to be hoped that the demand for these reprints will justify the Association in publishing similar reprints of contributions to future meetings.

Our Astronomical Column.

A STUDY OF OBSCURE NEBULÆ.—There have been many notes in recent years on regions of the sky where there is a deficit in the star-density as compared with neighbouring regions, the explanation generally assigned being an obscuring veil of dark nebulosity. We may refer in particular to one in Mon. Not. R.A.S. for November 1920 dealing with some barren regions in Taurus as shown on the Franklin Adams charts. Rev. J. G. Hagen, S.J., Director of the Vatican Observatory, has been examining these regions for the last ten years with the 16-inch refractor at the Observatory. He states that he can see these nebulosities, not as dark objects, but as faintly luminous ones. He discusses their distribution in *Scientia* for March; they are seen in all parts of the sky, but are densest towards the galactic poles, and diminish in extent and density as the galaxy is approached. He states that they are entirely absent in rich galactic star fields, and supposes that the nebulous material has been wholly transformed into stars in these regions. He places the obscure nebulæ outside the galaxy and asserts that their greater faintness in low galactic latitude is the result of greater distance; this does not appear to be sound, as the surface brightness of objects of sensible area is unaffected by distance provided that the intervening space is perfectly transparent. There is the further difficulty that in such barren fields as those in Taurus there is a deficiency not only of distant stars, but apparently also of nearer ones, suggesting a much smaller distance for the obscuring cloud. Thus while the visual study of these interesting regions is thoroughly useful work, there seems to be need of further examination of the significance of the results obtained.

SPECTROSCOPIC STUDY OF PROCYON'S ORBIT.—Dr. Lunt directs attention in *Astrophys. Journ.* for January to the aid that the spectroscope may render in the study of this system. The companion, discovered by Schaeberle in 1896, is a very difficult object and observations have been scarce of late. Dr. Lunt quotes the figures that he deduced from his measures on plates taken between 1909 and 1912. These appear to indicate a diminution in the approach of the principal star to the sun, which was 3·74 km./sec. in 1909 and 3·56 km./sec. in 1912; he points out that observations made now will be fairly decisive as to the pose of the orbit-plane, as there would be a difference of $1\frac{1}{2}$ km./sec. on the two assumptions. As one of the nodal passages is now at hand, the conditions are more favourable than they will be till 1938, when the other node is passed. He is himself arranging for a series of plates and asks for co-operation elsewhere. The approach of the centre of gravity towards the sun is given as 3·52 km./sec.; corrected for the sun's motion, the system is approaching with a speed of 19 km./sec. in a line inclined 14° to the line joining sun and star.

RECENT MAGNITUDES OF NOVÆ.—The appearance of a new star in the heavens at once attracts the attention of a large number of observers who follow very carefully the changes of magnitude and the variations in its spectrum. When, however, the magnitude has dwindled down to about 8 or 9, interest greatly diminishes; the star becomes too faint for spectroscopic analysis except with large telescopes, and the small and slow changes of magnitude are not watched by many observers. It is, however, very important to follow novæ so long as possible in order to keep in touch with the later variations. Great interest is, therefore, attached to the series of observations made by Dr. W. H. Steavenson of six novæ during the summer and autumn of 1921 (*Monthly Notices*, R.A.S., vol. 82, November 1921). Nova Ophiuchi (1848) gave evidence of variability in a period of about fifty days, the magnitudes varying from about 12 to 13. Nova Aquilæ (1918) is still slowly waning, the mean magnitude falling from 9·4 to 9·9, with a possible long-period variation. Nova Cygni (1920) is also still fading slowly, the mean magnitude during the period of observation falling from 9·4 to 10·0. Nova Cygni (1876), a star now very near the limit of visibility, exhibited practically a constant magnitude, namely, 14·81. The same is the case with Nova Lacertæ (1910), which has varied only 0·1 mag. from 14·1. On the other hand, Nova Persei (1901) has shown a marked variability of an irregular type, the two extremes of brightness being 12·27 and 13·36. The star was accompanied by a small patch of nebulosity about 5″ in diameter.

Research Items.

The Organism and Environment.—In an article on "The Organism and its Environment" (*Scientific Monthly*, March 1922), Dr. F. B. Sumner emphasises the difficulty of drawing any sharp line between these two categories. Citing as examples the nest of a bird, the tube of a caddis-worm, the shell of a mollusc or a tortoise, the varying fluids and gases which circulate in animals from sponges to fishes or seals, and the many metabolic changes of substances entering or leaving the body, he shows that the distinction between organism and environment must often be difficult or arbitrary. Some of his remarks have a direct bearing on the discussion of biological terminology which has taken place recently in this journal. Thus he says, "Every character has a hereditary basis" and is likewise due to "interaction . . . with the . . . environment." He goes on to say, "The familiar question, Which is the more important, heredity or environment? is not capable of answer when stated in that form"; he points out that the question should be framed on these lines: Are the *differences* between related organisms in any particular case due to *differences* in heredity or to *differences* in environment? When stated in this way it is seen that some characters or differences are primarily due to heredity and some to environment, and the quibble about all characters being equally acquired and equally inherited ceases to be of scientific value.

Studies on Arthropoda.—Dr. H. J. Hansen has issued, "at the expense of the Rask-Orsted Fund," under the title "Studies on Arthropoda, I." (Copenhagen, 1921), three papers—one, illustrated with four plates, on a collection of Pedipalpi, etc., from West Africa, another on the post-embryonic occurrence of the median "dorsal organ" in Crustacea, malacostraca, and a third on stridulation in decapod Crustacea. In this last paper Dr. Hansen has brought together the records of the species of decapods in which stridulating organs are present, and gives an account of two further examples which he has discovered in a species of Ovalipes (one of the Portunidæ) and in Acanthocarpus (family Calappidæ). A stridulating organ consists usually of a regular row of small tubercles or a file-like series of ridges, *e.g.* on the carapace, which can be rubbed by a ridge, or a regular row of tubercles or ridges, or a sharp margin situated on some movable part of a neighbouring appendage. The sound produced by living crabs by means of the stridulating organ has been heard in the case of about half a dozen species. Dr. Hansen points out that a stridulating organ is developed in all species of Ocypoda except one, and in the Indo-Australian *Ocypoda ceratophthalma* one of the two series of ridges is composed of ridges of two sizes, coarse and very fine, so that the tone produced is deep or high, according as the coarse or fine ridges are rubbed. In discussing the use of the stridulating organ Dr. Hansen quotes Col. Alcock's view that this organ serves the crab to give warning to trespassers of its own species about to enter its burrow, but he suggests that some naturalist who has at his disposal living examples of Ocypoda should carry out investigations with the view of elucidating further the use of these organs.

Hygrometry.—The report of the discussion on hygrometry which was held by the Physical Society of London in November last has been issued with the Proceedings of the Society for February 15. It extends to 95 pages and is the most comprehensive publication on the subject which has appeared for many years. For some time one of the principal problems of hygrometry has been to develop a method which would determine, with an accuracy of 1 per cent., the fraction of saturation of air at temperatures below the freezing-point of water. The chemical method of absorbing the moisture is quite satisfactory at ordinary temperatures, but at temperatures below the freezing-point, the weight of moisture present is small and the method becomes difficult owing to the deposition of dew on the weighing tubes and other apparatus used. The dew-point method in its various forms is applicable at all temperatures and has been employed at the National Physical Laboratory as the standard of reference. The wet and dry bulb instrument fails at temperatures below the freezing-point, while the hair hygrometer continues to act although its indications are not always trustworthy. There appear to be some grounds for taking the decrease in length of the hair from its length when saturated as proportional to the logarithm of the relative humidity down to a relative humidity of 10 per cent.

Liquid Inclusions in Glass.—Some interesting experiments on the production of liquid inclusions in glass, made by Mr. Charles E. Benham, are described in the *Geological Magazine* for March. Although liquid inclusions in crystals of sodium chloride, alum, and other salts resemble in many respects those in quartz and exhibit Brownian movement of the more minute enclosed bubbles, there is reason to believe that their origin is not the same. Artificial inclusions approximating more closely to the cavities in minerals were prepared by boiling resin in water tinted with gamboge. Some of the cavities produced contained small quickly moving bubbles, and in others the gamboge particles were in rapid motion. In order to form similar artificial inclusions in glass approximating more nearly to those found naturally in quartz, a small glass tube about 3 inches long and a quarter inch external diameter was partially filled with water and sealed at both ends. It was enclosed within an unbaked brick and submitted to the usual process of firing in a brick kiln at a temperature of about 1200° C. After this treatment the glass was found to contain microscopic liquid inclusions with vapour bubbles comparable with those found in quartz. The experiment was repeated with similar results.

The Atomic Weight of Chlorine.—From the researches of Dr. F. W. Aston it is known that ordinary chlorine, atomic weight 35·46, is a mixture of two isotopes of atomic weights 35 and 37. The constancy of this ratio has been proved by the concordance between the determinations of the atomic weight made in different laboratories. This chlorine, without exception, came from minerals deposited by sea water. There is a possibility that the ratio might not be the same in chlorine arising from primary minerals not deposited from sea water, and this question has been taken up by Mlle. Ellen Gleditsch and B. Samdahl (*Comptes rendus*, March 13). They prepared salt from an apatite (calcium chlorofluophosphate) found in primary rocks, and after careful purification from fluorine, bromine, and iodine, found the atomic weight of the chlorine to be 35·49, 35·45, 35·46, the same as that of ordinary chlorine. Hence at the time of the formation of the minerals of the primary magma, the two chlorine isotopes were in the same ratio as at the present time.

The British Cotton Industry Research Institute.

THE new laboratories of the British Cotton Industry Research Association, at the Shirley Institute, Didsbury, Manchester, were formally opened by H.R.H. the Duke of York, K.G., on March 28. His Royal Highness was welcomed by the Chairman of the Council, Mr. Kenneth Lee, and the Director of Research, Dr. A. W. Crossley, in the presence of about 1500 guests, including representatives of most of the Universities. Mr. Kenneth Lee gave a brief review of the development of mechanical skill in the cotton trade, and explained how it was that the present leaders in the industry had become so convinced of the need for scientific inquiry on a large scale that, with the help and encouragement of the Department of Scientific and Industrial Research, they had established an Association for research on a co-operative basis. He spoke appreciatively of the help which University laboratories could contribute, and pleaded for their sympathetic co-operation, but he explained that the application of scientific methods and discoveries which were so much needed by the industry could be rendered most effectively by a group of scientific workers making their experiments in a special institution where they could obtain a closer knowledge of the processes involved than can be gained during an academic career.

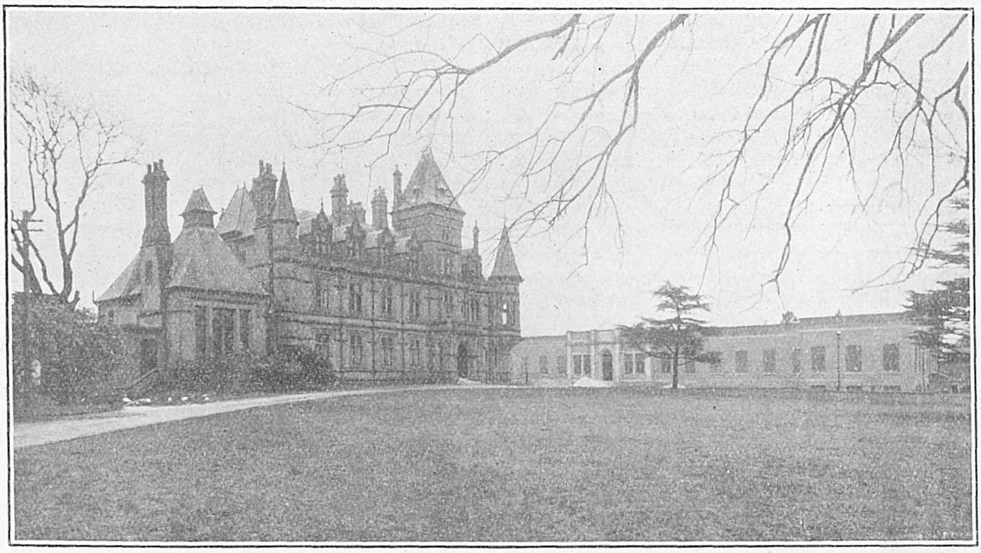

FIG. 1.—The Shirley Institute for Cotton Research.

His Royal Highness, in declaring the Institute open, congratulated the Association on securing the loyal support of the vast majority of the firms engaged in the industry and the various organisations of Labour, and emphasised the Imperial value of the close union which existed between the Research Association and the Empire Cotton-growing Corporation.

So far back as May 23, 1917, the opinion was expressed at one of the meetings of the provisional committee which organised the Cotton Industry Research Association that "the site of the Research Institute should not be less than five acres in extent; that it should be in pleasant surroundings, free from vibration due to traffic, and easily accessible both from the University (of Manchester) and from the centres of industry." These conditions are admirably fulfilled in the Shirley Institute, to which brief reference has already been made in NATURE (1920, vol. cvi. pp. 411-413). The house and laboratories are nearly 250 yards from the main road, the grounds are bounded on the south by open fields, the prevailing winds leave the air free from the smoke clouds of both Manchester and Stockport, and the centre of the city can be reached in about half an hour.

The new laboratories have been designed to secure maximum adaptability, since it is almost impossible to predict which will be the predominant department in a few years' time. A "unit size" room has been created, and the separate laboratories are made in multiples of this unit. All the equipment is, so far as possible, uniform in design, and future extensions of the laboratories will be carried out on the same plan, so that the physics department, for example, could be moved to another portion of the building with the knowledge that all its furniture would fit into the new rooms.

The ground plan of the new laboratories, representing two-fifths of the projected scheme, is given in FIG. 2. The completed portion is a one-storey building, divided into a central block 170 ft. × 54 ft., and an end block 83 ft. × 32 ft., the former being subdivided by the entrance hall and a long corridor into four departments each 22 ft. wide, which are partitioned off by breeze-block walls into one-, two-, or three-unit rooms as best adapted to the special requirements of the department. The outer walls, 21 in. thick, and the walls of the corridor bear the weight of the saw-tooth roof, which provides for north lighting. The span of each section of the roof is 10 ft. 6 in., and therefore the "unit room" is 22 ft. × 10 ft. 6 in.

All the supply lines, including 4-in. gas and water mains, hot-water, steam, and compressed air circuits, electric lighting and power cables, lead from the special battery of twenty two-volt "Exide" cells, and telephone wires are carried along a passage 5 ft. high under the central corridor. The branch lines for the different rooms of the central block are brought under the floors, the secondary mains for gas and water being closed circuits with control valves at each end. The drainage pipes also pass first into the sub-floor, the height of which is 3 ft. 6 in., so that all vital supply and waste systems are accessible at any time. The laboratories are heated by radiators at the floor level, and hot-water pipes are also conveyed around the ceilings to prevent down-draughts from the glazed roof.

With the exception of the main chemical laboratory and balance-room, none of the rooms have fixed benches. In most cases the supply-lines and small sinks are held in position by a narrow shelf attached to the walls at the standard height of the window sills, and working accommodation is provided by tables of the same height, which are arranged in accordance with the needs of the work in progress. In the physics department stout battens are screwed to the walls at two different heights from the floors and the gas connexions and any apparatus which is to be mounted for a considerable time are attached to these battens. Fume cupboards, where necessary, are built into the window spaces, and mounted on wide concrete shelves covered with Ruabon tiles, the draught being induced by gas-burners placed in the flues at the floor level. Bright metal taps and electric switches have been avoided entirely so as to minimise the labour of cleaning.

The work of the botanical department is chiefly microscopical, and special attention has been given to various forms of artificial illumination. Each microscopist has at his disposal two gas leads, a small sink, an electric power point for microscope illumination, an electric lighting point for bench lamps, and low-voltage currents from overhead wires for warm-stage work and incidental illumination. A fire-proof and sterilisable room is reserved for bacteriology, and contains electric incubators and sterilisers mounted on concrete benches, and a gas autoclave under a ventilating hood. The department has a very large number of samples of cultivated and semi-wild varieties of cotton, and obtains further material for study from an experimental greenhouse in which about 300 cotton plants can be grown at one time. The physics department is fully equipped for research into the physical and mechanical properties of single cotton hairs, carded cotton, slivers, yarns, and fabrics. Each room is well supplied with electric power points, and is wired for six independent circuits from the battery. Two of the rooms, having concrete floors paved with wood blocks, are reserved for experiments with delicate pieces of apparatus which demand freedom from vibration. The main chemical laboratory, 40 ft. × 30 ft., is a very bright room with walls covered with white tiles up to a height of 8 ft. Furnaces, thermostats, and large pieces of apparatus are accommodated on a tiled, concrete shelf, and a special bench is reserved for distillations. The working benches, 27 ft. long, are made of pitch-pine with teak tops. Large glazed sinks are provided at each end, and the drainage from the taps and filter-pumps which range along the benches is taken by glazed channels. All the sinks discharge into loose mixing traps before emptying into the drains.

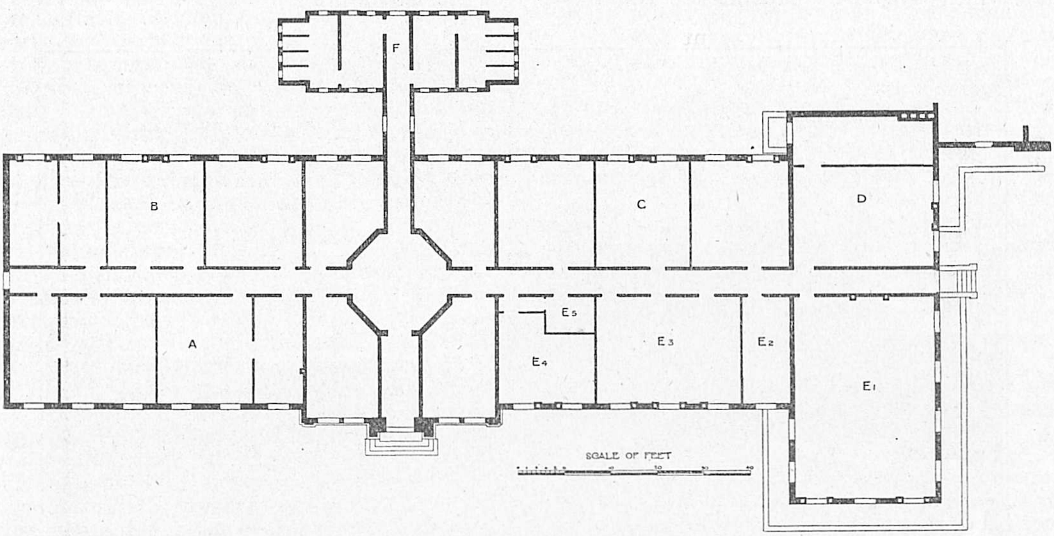

FIG. 2.—Ground Plan of New Laboratories.

A. Department of Physics.
B. Department of Botany
C. Department of Colloids
D. General Stores.
E_1. Main Chemical Laboratory.
E_2. Balance Room.
E_3. Unoccupied.
E_4. Optical Room.
E_5. Photographic Dark Room.

Below D is the boiler-house, and under E_1 a machinery room.

The importance of the subject of colloids for the cotton industry has been recognised by the creation of a separate department of colloid chemistry and physics. The three rooms are well equipped for physico-chemical research, one with a concrete floor being reserved for experiments which demand freedom from vibration or cause chemical fumes. Special accommodation for optical work is provided in a large room which has the roof lights completely obscured, the windows fitted with roller blinds, and all the walls, woodwork, and furniture painted a dead black. One corner of this room has been partitioned off and fitted as a photographic dark room, both parts being ventilated by a light-tight electric fan.

The coach-houses and stables of the estate have been converted into workshops for the construction and repair of instruments used in the laboratories and for the general maintenance of the Institute. Ample accommodation has been secured for smith's and carpenter's work and general machining on the ground floor, and for a scientific glass-blower above. These experimental workshops have already proved to be of enormous value to the Institute in equipping the new laboratories and making new devices for the testing of cotton yarns.

The National Institute of Industrial Psychology

A LARGELY attended meeting of the National Institute of Industrial Psychology was held at the Mansion House, London, on March 27, at which the principal speakers were Viscount Haldane, Mr. W. L. Hichens (Chairman of Messrs. Cammell Laird & Co., Ltd.), and Dr. C. S. Myers (Director of the Institute). The chair was occupied by Mr. H. J. Welch (Director of Messrs. Harrisons and Crosfield, Ltd., and Chairman of the Institute). The following resolution, moved by Dr. Myers and seconded by Mr. Hichens, was carried unanimously:

"In view of the present serious economic situation and of the necessity to reduce costs of production and to increase the total national output, this meeting is of the opinion that: (*a*) a more complete and scientific development of the nation's human resources and a reduction of wasteful and misapplied energy are matters of urgent national importance; (*b*) the methods adopted by the National Institute of Industrial Psychology have been shown to reduce costs of production, to promote the development of individual ability, to eliminate unnecessary effort and fatigue, and to improve the health and well-being of the worker; (*c*) it is imperative that a national fund should be immediately established to enable the institute to extend its sphere of usefulness and to continue the necessary researches into the scientific problems involved."

The following letter was read from Mr. Seebohm Rowntree: "I am sorry I cannot be present, for I should have been glad of an opportunity to speak of the services of the institute to the cocoa works at York. We have felt for some time that benefits would accrue if some of the human factors affecting efficiency were studied on a more scientific basis. . . . It was a great advantage to be able to turn to an institute like yours and to secure from you not only a trained worker to make actual observations among the workmen, but the services of a skilled psychologist to direct him. It has shown us how important are the researches still to be made in our own factory by psychological experts."

Mr. Harry Salmon (Managing Director of Messrs. J. Lyons and Co., Ltd.), in proposing a vote of thanks to Viscount Haldane for his address, expressed his pleasure and satisfaction at the work carried out by the institute in the factories and depots of his firm. The output of the packing department of the chocolate factory had been increased by over 35 per cent., and at the same time the amount of effort and fatigue of the workers had been reduced. Similar results were being obtained in other departments of the firm.

Dr. Myers emphasised the value to the employees of the institute's work. Many workers, he said, have expressed their gratitude spontaneously to the investigators for the reduced fatigue felt at the end of the day. The form of the daily output curves before and after the investigations has actually demonstrated the reduction in the workers' fatigue.

The institute, he said, also aims at guiding the young worker in the choice of his occupation, submitting him to detailed examination by applying to him a series of mental, physical, and medical tests, and considering the results in conjunction with school records. These tests serve also to guide the employer in selecting the most capable applicant for a vacant post. They are not intended to replace the ordinary interview, but to supplement it by the measure they afford of the candidate's general intelligence, and of his endowment with the special abilities required for the particular job. The institute has already, thanks to the investigations of Mr. Cyril Burt, formulated satisfactory tests for shorthand writers and typewriters. Mr. Muscio's tests for selecting compositors, published by the Industrial Fatigue Research Board, have proved equally valuable.

In the United States numerous bureaux of vocational guidance are scattered over the whole country. Occupational tests are to-day being applied in America for the selection of sales clerks, proofreaders, clerical workers, inspectors, assemblers, and other types of factory workers. Mental tests have been introduced in place of, or as complementary to, the ordinary entrance examinations in several important universities of America. At the Carnegie Institute of Technology in Pittsburgh (in the University of which there are over 2000 students of psychology) the Bureau of Personnel Research is maintained financially by a number of industrial and commercial firms, who thus obtain information relating to the selection, training, organisation, and supervision of their personnel. Single firms or groups of firms arrange with the Carnegie Institute for special research on the problems arising in their factory, office, sales, or executive organisation. Instruction and research on vocational psychology are carried on in most of the American universities.

In Barcelona, the Institute of Vocational Guidance is supported entirely by the city and by the province of Catalonia. Over a thousand applicants for advice pass through its hands every year. In Brussels a similar rate-supported vocational guidance bureau is doing most valuable work, abolishing the huge number of occupational misfits and thus reducing not only the vast expense of a needlessly large labour turnover but also the overstrain and unhappiness of the misguided worker. In Germany laboratories concerned with industrial psychology and physiology have been established in Berlin, Frankfurt, Leipzic, Munich, and other large centres. The Allgemeine elektrische Gesellschaft, the Osram Company, the Berlin Tramways, Siemens and Halske may be mentioned among the firms which have availed themselves of the services of such institutes, especially in the selection of workers in their principal departments. It is stated that during twelve months the Grosser Berliner Strassenbahn has saved over twelve million marks as a result of the application of vocational selection, proper training based on motion study, etc. Indeed, Germany hopes to secure a lead in commerce and industry by paying attention to their *human* aspect, just as in pre-war days she advanced by paying attention to their *material* aspect. Her trade unions are likewise recognising the value of vocational guidance and of systematic training in approved methods of work.

Viscount Haldane, in the course of an eloquent address, stated that there was no problem more menacing than that of unrest arising out of the relations of Labour to Capital. We had reached a stage at which the merely mechanical work was being done more and more by the machine, while the worker was becoming more and more engaged in the directing of the machine. In other words, mind was becoming of ever-increasing importance; indeed it was not capital that created wealth, nor labour, but mind. One of the objects of the institute was, so far as possible, to relieve labour from the feeling that men and women were only machines. The aim of the institute was not to secure increased output at all costs to the worker, but to improve the mental, physiological, and physical conditions under which he worked and by this means to increase his efficiency. We were beginning to realise that the workman, although he is not a machine, needs to be studied with the same scientific care and methods as are now applied to a machine, and within twenty years, he imagined, the expert in psychology and physiology would be at the elbow of every manager of a great business. If this were done we should have taken a step towards securing the contentment of the workers, because they would, at the end of their day's work, be fresh enough to turn their attention to that spiritual refreshment and knowledge which would give them the full meaning of life.

Gas Cylinders Research.

The first report of the Gas Cylinders Research Committee has just been published by the Stationery Office. The Committee was appointed in 1918 to inquire into the whole question of cylinders for the storage and transport of compressed gases other than acetylene, but the present report deals only with the material for cylinders for the so-called permanent gases which are not liquefied at the pressures prevailing in the cylinders. The main question under discussion was the advisability of using steel of higher carbon content than has hitherto been permitted in this country, the regulations based on the recommendations of the 1895 Committee requiring that the carbon should not exceed 0·25 per cent., whilst in America the carbon may be as high as 0·55 per cent. The railway companies favour the continuance of this restriction, arguing that the immunity of this country from cylinder accidents as compared with foreign countries points to the desirability of using only low-carbon steel. On the other hand, it is shown that cylinders of steel containing 0·43-0·48 per cent. of carbon have given perfectly satisfactory tests at the National Physical Laboratory, and that such cylinders are at present carried by road, whilst the railways conveyed a large number of hydrogen cylinders of this composition during the war under an indemnity from the Admiralty.

The Committee was not able to arrive at a unanimous decision. Eleven of the members sign the main report, in which steel of the higher content in a normalised condition is recommended as an alternative material, the stress tests and tests for toughness being specified. The chairman, Prof. H. C. H. Carpenter, and the scientific members of the Committee are agreed on this point. The dissenting member, Mr. J. H. B. Jenkins, is of opinion that high-carbon steel is not only less tough, but also more liable to variations in quality than mild steel, and that the saving in weight which would be effected by the change is too small to justify even a slightly increased risk of accident. The report contains a long account of mechanical tests and microscopical examinations, and will be found of interest by all steel metallurgists, whether they are concerned with the immediate problem or not.

University and Educational Intelligence.

Aberdeen.—At the spring graduation ceremony on March 30 the honorary degree of doctor of laws (LL.D.) was conferred upon Prof. T. W. Griffith, Professor of Medicine, University of Leeds; Mr. John Masefield; and Dr. C. H. Turner, Dean Ireland's Professor of Exegesis, Oxford. The following higher degrees were also conferred. *Science: D.Sc.*, G. P. Hector, Agricultural Department, Dacca, India. Thesis—"Studies in the Botany and Genetics of Rice." *Medicine: M.D.*, F. W. C. Brown. Thesis—"A Critical Investigation into the Thermal Death Point of the Tubercle Bacillus in Milk, with Special Reference to its Application to Practical Pasteurisation." J. G. Danson. Thesis—"Anaphylaxis: its Relationship to Asthma and Hay Fever." M. Y. Garden. Thesis—"Observations on the Treatment of Diseases of the Lungs and Pleura by Artificial Pneumothorax." R. D. Lawrence. Thesis—"The Estimation of Diastase in Blood and Urine and its Diagnostic Significance." *Ch.M.*, Dr. W. Brander. Thesis—"Spontaneous Rupture of the Pathological Spleen."

London.—The following doctorates have been conferred:—*Ph.D.* (*Science*) on Mr. J. Mould for a thesis entitled "The Properties of Dielectrics, including the Variations of Dielectric Constant with Frequency, the Energy dissipated therein and the Variation in Conductivity," and on Mr. G. Sheppard for a thesis entitled "Contributions to the Geology of Southern Alberta and Saskatchewan, Canada, with detailed reference to the Stratigraphy and Structure of the Foothill Belt and its Associated Areas"; and *Ph.D.* (*Economics*) on Bal Krishna for a thesis entitled "Commercial Relations between India and England."

The Lindley Studentship, of the value of 120*l.*, offered every third year, will be awarded to assist research in physiology in the physiological laboratory. Candidates should submit a statement of qualifications and the mode of research proposed to the Academic Registrar by May 1.

Three Research Studentships for post-graduate work, of the value respectively of 175*l.*, 105*l.*, and 75*l.* (with remission of school fees in addition), and available for two years, will be awarded in July next by the London School of Economics and Political Science. Applications, upon a special form obtainable from the director of the school, Houghton Street, W.C.2, must be sent in by, at latest, May 31.

Manchester.—A Fellowship for the encouragement of research in preventive medicine has been instituted in memory of the late Auguste Sheridan Delépine, professor of public health and bacteriology in the university from 1891 to 1921, by the addition of the emoluments of the former Junior Research Fellowships in Public Health to the interest derived from an endowment of 1000*l.*, made by Dr. Charles Slater of Tunbridge Wells. The regulations which have now been approved provide for a Fellowship of 300*l.*, to be offered biennially and to be open for competition by candidates who are graduates in medicine of this or any other approved university, or who hold an approved registrable medical qualification.

The Ashby Memorial Research Scholarship in Diseases of Children, value 100*l.*, is being offered this session. Applications for the scholarship, with information as to the subject proposed for investigation and the qualifications of the candidates, should reach the Internal Registrar of the university before June 30.

We referred in these columns on March 6, p. 325, to a scheme put forward by the Colston University Research Society, of Bristol, for the establishment of Colston Research Fellowships in the University of Bristol. Already the Society announces that Messrs. J. S. Fry and Sons, Ltd., Messrs. E. S. and A. Robinson, Ltd., and Messrs. C. Thomas and Bros., Ltd., have each promised to contribute the 150*l.* annually necessary to found Fellowships. It is to be hoped that the lead given by these firms will be quickly followed by other local manufacturers.

Calendar of Industrial Pioneers.

April 7, 1898. **Otto Baensch died.**—For nearly fifty years Baensch was in the State service of Germany and did important work in connection with the navigation of the Elbe, the Upper Rhine, and the famous Kaiser-Wilhelm or Kiel Ship Canal.

April 8, 1893. **Vice-Admiral E. Paris died.**—Joining the French Navy in 1822, Paris was one of the first naval officers in France to study steam navigation. He wrote manuals on mechanics and a treatise on screw propulsion, and contributed papers to the Institution of Naval Architects, of which he was elected an honorary associate.

April 9, 1870. **Thomas Joseph Ditchburn died.**—A pioneer builder of iron ships, Ditchburn received his training in Chatham Dockyard and assisted Sir Robert Seppings in some of his experiments. He afterwards was manager for Fletcher and Fearnall, and then with Mare established the first iron shipbuilding yard on the Thames. In 1846 he built the only iron sailing man-of-war ever in H.M. Navy, H.M.S. *Recruit*. Ditchburn later on founded the famous Thames Iron Works at Blackwall, where during ten years he constructed some 400 vessels.

April 9, 1877. **William Gossage died.**—A great industrial chemist and inventor, Gossage began life as a druggist's assistant. In 1830 he assisted to found an alkali works at Stoke Prior, Worcestershire, and six years later he patented his well-known condensing tower which prevents the escape of hydrochloric acid gas; an invention "which saved from extinction a trade, the growth of which has contributed to the nation's prosperity." Gossage engaged in copper smelting and other enterprises and also became the largest manufacturer of soap in the world.

April 10, 1903. **Horace Bell died.**—Entering the public works department of India in 1862, Bell rose to be Engineer-in-chief of the Survey of the Great Western Railway of India and consulting engineer for the State railways.

April 11, 1822. **Ralph Dodd died.**—The projector of a tunnel beneath the Thames between Tilbury and Gravesend, Dodd was a civil engineer and was known for his writings on canals and on the water supply and docks of London; he was also a promoter of steam navigation. He died just a hundred years ago from injuries sustained by a boiler exploding.

April 11, 1847. **Charles Holtzapffel died.**—The son of a German toolmaker who settled in London in 1787, Holtzapffel became an expert mechanician, and in 1843 published a valuable work entitled "Turning and Mechanical Manipulation." He was a member of the Council of the Institute of Civil Engineers.

April 12, 1840. **Franz Anton von Gerstner died.**—Like his father a mathematician and engineer, Gerstner from 1818 to 1825 was professor of practical geometry in the polytechnic in Vienna, and was one of the earliest continental railway engineers. He constructed the railway from Budweis to Linz, and in 1834 built the first Russian line, that from St. Petersburg to Czarskoeselo. He died in Philadelphia, whither he had gone to study the railways of America.

April 12, 1898. **Aimé Claude Alfred Girard died.**—A distinguished French chemist, and a member of the Institute, Girard in 1871 succeeded Payen in the chair of industrial chemistry in the Conservatoire des Arts et Metiers.

E. C. S.

Societies and Academies.

LONDON

Royal Society, March 23.—Sir Charles Sherrington, president, in the chair.—Sir Richard **Glazebrook**: Specific heats of air, steam, and carbon dioxide. The values for the specific heats of these gases below 1000° C. given recently by Womersley are higher by 5-10 per cent. than those which follow from the results given by Holborn and Henning.—A. E. H. **Tutton**: (1) Monoclinic double selenates of the manganese group. The manganese group of double selenates of the isomorphous series $R_2Mn(SeO_4)_2 \cdot 6H_2O$ includes only three salts, those in which R is rubidium, cæsium, and ammonium. Optically these salts are precisely in line with those for analogous salts of other groups, so that if the potassium salt could be obtained, it would be the first member of a progressive series, and the general law of progression of the crystallographic properties with the atomic number of the alkali metal would be obeyed rigidly. The volume and edge-dimensions of the space-lattice cells of the crystal structures of ammonium manganous selenate hexahydrate and rubidium manganous selenate are nearly identical. Similar facts obtain for all analogous ammonium and rubidium salts throughout the whole isomorphous series, as well as for the rhombic simple sulphates themselves. (2) Monoclinic double selenates of the cadmium group. Crystals of the ammonium salt, $(NH_4)_2Cd\ (SeO_4)_2 \cdot 6H_2O$, which were sufficiently transparent in parts for optical use were obtained on very keen frosty nights. The potassium salt appears to be incapable of existence, its limit being probably below 0° C. Crystals of the rubidium or cæsium salt were obtained during the coldest nights of January, but they were quite opaque, so that only goniometrical measurements were possible. The results are in complete accord with those from other, complete groups.—F. A. **Freeth**: The system: $Na_2O—CO_2—NaCl—H_2O$. The system is arbitrarily considered as composed of two four-component systems, namely:—$Na_2CO_3—NaHCO_3—NaCl—H_2O$, and $Na_2CO_3—NaOH—NaCl—H_2O$. Determinations have been made at 0°, 15°, 20°, 25°, 30°, 35°, 45°, and 60° C. A general treatment is given showing how the composition and quantities of the stable phases from any mixtures of the components may be deduced.—M. A. **Catalán**: Series and other regularities in the spectrum of manganese. Flame-arc, arc and spark spectra of manganese have been observed and new series lines traced. Series belonging to the spectrum of the neutral atom are (*a*) a system of triplet series; (*b*) a system consisting of narrow triplets; and (*c*) a system of narrower triplet series running parallel to the preceding system. Intercombination lines between the two first systems appear as two lines very prominent at low temperatures. The calculated ionisation and resonance potentials of manganese are 7·4 volts and 2·3 volts. Diffuse triplets in the spectrum of the ionised atom are composed of nine lines. At different temperatures, groups of lines of the same character and related by very exact numerical separations ("multiplets") have been identified. The neutral atom of manganese probably has two electrons in the outermost ring, and when it loses one electron and becomes ionised, another electron comes out to the ring. Thus, the spectra of neutral and ionised atoms would be similarly constituted in accordance with observations.—D. W. **Dye**: Calculation of a standard of mutual inductance and comparison of it with the similar laboratory standard. The windings of the primary helices and the secondary overwound coil of a Campbell type of mutual inductance standard were measured in terms of the length standards of the N.P.L. and the value in absolute millihenries has been calculated. Comparisons with the similar laboratory standard at a frequency of ten cycles per second showed that the ratio of the calculated values of the two standards was in agreement with the ratio of the experimentally compared values to an accuracy of 5 in 10^6.—P. E. **Shaw** and N. **Davy**: The effect of temperature on gravitative attraction. Results with a torsion balance of the Boys-Cavendish type indicated a temperature effect of gravitation of about 1×10^{-5} per 1° C. With similar apparatus modified to eliminate small mechanical movements caused possibly by the raising of the large gravitative masses to a high temperature, the effect was shown to be due to such movements reversible with temperature. The temperature effect, if any, must be less than 2×10^{-6} per 1° C. The mean effect observed is a very small diminution in attraction as temperature rises.

Zoological Society, March 7.—Sir Sidney F. Harmer, vice-president, in the chair.—N. S. **Lucas**: Report on the deaths which occurred in the Society's Gardens during 1921.—R. **Broom**: On the temporal arches of the Reptilia.—F. V. **Urich**, H. **Scott**, and J. **Waterston**: The bat-parasite *Cyclopodia greeffi*, and a new species of hymenopterous (Chalcid) parasite bred from it.—S. V. **Montgomery**: Direct development in a Dromiid Crab.—F. **Balfour-Brown**: The life-history of the water-beetle, *Pelobius tardus*, Herbst.

March 21.—Dr. A. Smith Woodward, vice-president, in the chair.—P. Chalmers **Mitchell**: Monkeys and the fear of snakes.—G. **Blaine**: Notes on the zebras and some antelopes of Angola.—R. I. **Pocock**: On the external characters of some Histricomorph Rodents.—H. R. **Hogg**: Some spiders from South Annam.

Physical Society, March 10.—Dr. Russell, president, in the chair.—R. L. **Smith-Rose**: On the electromagnetic screening of a triode oscillator. The most complete method of screening a valve set is to enclose it in a hermetically sealed box made of metal of suitable thickness for the frequency used. The smallest crack allows a detectable amount of the high-frequency energy to escape. Iron is far more effective than copper of the same thickness in preventing direct penetration of radio-frequency magnetic fields through the metal.—H. P. **Waran**: A new form of high vacuum automatic mercury pump. The pump, based on a modified Sprengel action, works automatically, the mercury being removed from the lower to the upper reservoir mixed with a current of dry air which is sucked through a side tube by a filter pump. An intermediate reservoir in the middle of the fall tube, kept automatically exhausted by the Sprengel action in the lower fall, allows the upper half to exert a positive exhaustion for every pellet of mercury falling down. The absence of compression in the first fall makes it possible to use the maximum bore for the fall tube. Less than a pound of mercury is required to operate the pump.—W. N. **Bond**: Viscosity determination by means of orifices and short tubes. General expressions for the end-corrections obtained by the method of dimensions are employed in plotting the results of experiments on the flow of mixtures of glycerine and water through pairs of tubes of equal diameter, but of different lengths. The conditions that the flow at the ends may be purely viscous and equations for determining the viscosity are given.

Royal Meteorological Society, March 15.—Dr. C. Chree, president, in the chair.—E. M. **Wedderburn**: Seiches; and the effect of wind and atmospheric pressure on inland lakes. "Seiche" is the name originally given in Switzerland to quasi-tidal movements of the level of inland lakes. In 1905 the late Prof. Chrystal investigated the seiches in Loch Earn for the Scottish Lake Survey, and found that microbaric disturbances were the most frequent cause of seiches. Other possible causes are heavy rainfall over part of the lake, rapid flooding and wind squalls. Earth tremors rarely cause considerable movements. The Scottish Lake Survey also discovered internal seiches of large amplitude. During autumn there is at the surface a layer in which there is little variation of temperature with depth. Below this is a narrow layer, the discontinuity layer, in which the fall of temperature is rapid, while below this again is the bottom water of the lake in which temperature variations are small. The effect of wind blowing along a lake is to accumulate the warm surface water at the lee end, so that the discontinuity layer is displaced from its normal horizontal position. When the wind moderates a standing oscillation commences at the discontinuity layer. The period of oscillation depends on the difference of density between these layers; the amplitude may be several feet, without causing measurable disturbance of the level of the free surface.

Cambridge.

British Mycological Society, March 18.—Mr. F. T. Brooks, president, in the chair.—Mrs. M. N. **Kidd**: Diseases of apples in storage. Moulds attacking apples in storage show a definite sequence and cause a different amount of loss. Physiological diseases are of considerable importance. Scald and probably others can be completely controlled by wrapping the fruit in specially prepared paper.—J. **Line**: Parasitism of *Nectria cinnabarina*. This fungus is associated with a characteristic wilting of apparently healthy branches, the wood of which is brown to green and occluded with fungal hyphæ. Pure cultures of the fungus were incapable of establishing the hyphæ in living wood or cortex but succeeded on artificially killed plants, and finally were able to pass into healthy wood.—K. C. **Mehta**: Observations on the occurrence of wheat rusts near Cambridge. *Puccinia graminis* does not overwinter by uredospores nor by mycelium inside the host plant; its recurrence is explained only through fresh infection by æcidiospores produced on Barberry. In *P. triticina* and *P. glumarum* viable uredospores can be found during the greater part of winter, and there is conclusive experimental evidence that these rusts can overwinter by means of mycelium inside the host plants.—F. T. **Brooks** and C. G. **Hansford**: Mould growths on cold store meat. Meat from the southern hemisphere showing mould growths was investigated. Some of these fungi, particularly *Cladosporium herbarum* ("black spot"), can develop at −6° C.; other moulds grow readily at temperatures about freezing-point. At several degrees above this, bacterial growth is so active as to suppress the moulds. The fungi are only superficial and, unless accompanied by putrefactive bacteria, do not render the meat unfit for food.

Dublin.

Royal Dublin Society, March 28.—Dr. J. A. Scott in the chair.—J. J. **Nolan** and J. **Enright**: Experiments on the electrification produced by breaking up water, with special application to Simpson's theory of the electricity of thunderstorms. Different samples of water were tested. The purer water gives higher charges, the difference being very great for small degrees of breaking-up. With more complete pulverisation the charge produced tends to be independent of the purity. It is found that the purer water can be broken into finer drops. Charges are obtained about ten times as great as any reported previously. The probable charge produced by the natural breaking up of a rain-drop of 4 mm. diameter is 0·2 e.s. unit per c.c.

EDINBURGH.

Royal Society, March 20.—Prof. F. O. Bower, president, in the chair.—Address by Sir Charles **Sherrington**: Some points regarding present-day views of reflex action. More attention is being paid now than formerly to the intimate nature of the processes in the nervous centres during reflex action. The question has been raised as to whether the essential elements of reflex action as unfolded in the reflex centre itself contain any which are fundamentally different from the properties shown by simple peripheral nerve-muscle preparations. The resemblance between the neuro-muscular junction and the synapse suggests that the latter, like the former, is a junctional region exhibiting decremental conduction of the nervous impulse. Then much of the summation observable in the nervous centre could be accounted for by such timing in the sequence of centripetal impulses that the successive impulses fell in the conducting path at such frequency as to coincide with the period of supranormal phase in the conducting fibre. The larger impulses thus resulting would pass through the decremental block that suffices to extinguish smaller ones. A somewhat slow frequency of stimulus rhythm would thus succeed in making a stimulus effective which had been at the outset ineffective. Conversely a frequency of serial stimuli, each singly effective, but so timed as to follow one upon another at such interval as to fall within the period of relative refractory phase of the precedent impulse, would lead to impulses of subnormal extent. These on arriving at a region of decrement, a synapse, would fail to pass. A neurone occupied by such subnormal impulses would form a complete inhibitory block to any reflex arc of which it formed a link. Thus central inhibition could be established by successive impulses, the interval between which lay outside the period of absolute refractory phase but not so far outside as to escape that of relatively refractory phase. Lucas offers an explanation of reciprocal innervation by such rhythmic impulse adjustments as involve interference of impulses of this nature. By invoking changes in the degree of decrement in the decrementally conducting regions the reversal of reflex action can be explained. Thus A. Forbes accounts for the changing of reflex excitation into reflex inhibition by assuming that the intensity of decrement is increased by such agents as chloroform and ether. The similar reversal by fatigue lends itself to a similar explanation. Such properties, observable in the simple nerve-muscle preparation itself, can be made to explain the main essential features of action of the nerve-centres.

PARIS.

Academy of Sciences, March 6.—M. Emile Bertin in the chair.—The secretary announced the death of M. Max. Nœther, correspondent for the section of geometry.—G. **Julia**: New applications of conformal representation with functional equations.—H. **Villat**: A new problem concerning analytical functions and conformal representation.—R. **Lagrange**: The application of varieties of order p in an x space of n order.—B. **Gambier**: Point correspondence deduced from the study of the three fundamental quadratic forms of two surfaces.—A. **Planiol**: Organic yield of internal combustion motors.—G. **Camichel**: Surfaces of discontinuity.—C. **Nordmann** and **Le Morvan**: Observation of a singular phenomenon presented by the star θ of the Great Bear. From its spectrum, this star should belong to the solar type, but the intensity distribution in its spectrum corresponds with an effective temperature near that of the very hot hydrogen stars.—G. **Prévost**: Determination of the coefficients in the development in Laplace polynomials of a function of two variables.—M. **Labussière**: The geometrical existence of a general invariant of pencils of rays refracted according to Descartes' law, and its applications to geometrical optics and to radiation.—E. **Belin**: The telegraphic transmission of photographs, drawings, or manuscripts. The original is converted into a relief photograph on bichromate gelatine paper, and a stylus connected with a microphone is moved over this relief. Special arrangements are described for ensuring the synchronism of the transmitting and receiving mechanism. The efficiency of the apparatus has been proved by trials in America and in France.—G. **Claude**: The elimination of the heat of reaction in the synthesis of ammonia at very high pressures.—G. **Chaudron** and G. **Juge-Boirard**: The estimation of sulphur in iron pyrites. In the method in current use (solution in aqua regia) some sulphur occasionally separates. It has been found that by allowing the reaction to proceed at the ordinary temperature for 12 hours this error can be avoided.—H. **de Pommereau**: The reduction of ethyl benzoate and of some other benzene compounds by sodium and absolute alcohol. With ethyl benzoate the chief product is tetrahydrobenzylic acid, with a small proportion of tetrahydrobenzyl alcohol as a secondary product.—M. **Sommelet** and J. **Guioth**: The formic hydrogenation of the quaternary salts of hexamethylenetetramine. Hexamethylenetetramine chlorbenzylate boiled with formic acid gives a slow evolution of carbon dioxide. When gas ceases to be evolved, dimethylbenzylamine, $C_6H_5 \cdot CH_2 \cdot N(CH_3)_2$, can be isolated, in quantity corresponding with 60-70 per cent. of the theoretical yield.—A. **Allix**: Observations on relief sculpture by ice.—A. **Guilliermond** and G. **Mangenot**: The signification of the reticular apparatus of Golgi. It has been suggested that Golgi's apparatus has no real existence in the living plant and is caused by the preparation and staining of the section. With barley root as material, Golgi's experiments were repeated and confirmed, using not only Golgi's method, admittedly open to objection, but also the more certain technique of Cajal and Da Fano.—P. **Georgévitch**: The origin of the centrosome and the formation of the spindle in *Stypocaulon scoparium*.—Mme. A. **Pruvot**: A new and remarkable type of Gymnosome (Loginiopsis). A description of a new type of Gasteropod collected during the voyages of the Prince of Monaco in the region of the Azores. At the point where the mouth is usually situated this animal carries an appendix, in length about one-third that of the body. This is expanded near the summit into three fleshy lobes.—F. **Maignon**: The utilisation of the tissue diastases for the determination of the organ, the functional insufficiency of which is the cause of a pathological state. The application of this clinical method to the study of the physiological *rôle* of certain organs. Basedow's disease was proved to be caused not by the condition of the thyroid gland alone, since a mixture of diastases from the thyroid, ovary, and suprarenal glands was required to abate the symptoms. Eczema yielded to treatment with hepatic diastases, either alone, or mixed with diastase from other organs.—J. **Benoit**: The physiological conditions relating to the periodic nuptial adornment in birds. There is a close connection between the state of the testicular interstitial gland and the state of the nuptial adornment (change in colour of plumage). There is no such connection between the nuptial adornment and the intratubular seminal gland.—C. **Oberthür** and C. **Houlbert**: Convergence or parallel variation in the genus Holimede.—M. and Mme. G. **Villedieu**: Contribution to the study of anticryptogamic copper mixtures. The spores of Phytophthora (potato "disease") germinate freely in solutions of copper bicarbonate, but solutions of sodium sulphate (0·18 per cent.), potassium chloride (0·15 per cent.), sodium chloride (0·15 per cent.), or potassium nitrate (0·2 per cent.) arrest completely the germination of mildew. It would appear that the presence of copper in Bordeaux or Burgundy mixtures is of doubtful utility.—M. **Aron**: The determinism of secondary sexual characters in Tritons.—P. **Nottin**: The increased solubility and diastatic degradation of the nitrogenous materials of maize. Application to yeast manufacture.

Official Publications Received.

Department of the Interior: United States Geological Survey. Forty-second Annual Report of the United States Geological Survey to the Secretary of the Interior for the Fiscal Year ended June 30, 1921. Pp. 108. (Washington: Government Printing Office.)

Thirty-fifth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1913–1914. (In 2 parts.) Part II. Pp. viii+795-1481. (Washington: Government Printing Office.)

Annual Report of the Director, United States Coast and Geodetic Survey to the Secretary of Commerce for the Fiscal Year ended June 30, 1921. Pp. 147+36 charts. (Washington: Government Printing Office.)

Department of the Interior: Bureau of Education. Bulletin, 1921, No. 8: Foreign Criticism of American Education. By W. J. Osburn. Pp. 158. (Washington: Government Printing Office.)

Diary of Societies.

FRIDAY, APRIL 7.

DIESEL ENGINE USERS' ASSOCIATION (at Institution of Electrical Engineers), at 3.—H. Moore: Some Characteristics of Petroleum Oil used in Diesel Engines.

LONDON SOCIETY (at Royal Society of Arts), at 4.30.—Dr. C. W. Saleeby: More Light on London: or the Coal Smoke Curse and the Restoration of Daylight.

FOOD EDUCATION SOCIETY (at Caxton Hall, Westminster), at 5.30.—Miss A. D. Muncaster, and others: Discussion on Feeding in Institutions, with special reference to School Diet.

ROYAL AERONAUTICAL SOCIETY (Students' Section) (at 7 Albemarle Street), at 6.45.—Prof. L. Bairstow: Some Aeronautical Problems of the Early Future.

JUNIOR INSTITUTION OF ENGINEERS, at 8.—J. W. Maple: Engineering in Southern Persia.

ROYAL INSTITUTION OF GREAT BRITAIN, at 9.—Sir Ernest Rutherford: Evolution of the Elements.

SATURDAY, APRIL 8.

ROYAL INSTITUTION OF GREAT BRITAIN, at 3.—Sir Ernest Rutherford: Radioactivity (6).

INTERNATIONAL COLLEGE OF CHROMATICS (at Caxton Hall), at 3.15.—E. K. Robinson: Trees: their Colours and Coloration.

MONDAY, APRIL 10.

VICTORIA INSTITUTE (at Central Buildings, Westminster), at 4.30.—T. Roberts: Seven Decisive and Suggestive Scenes in the History of the Secular Contest between Conscience and Power.

ROYAL GEOGRAPHICAL SOCIETY (at Lowther Lodge, Kensington Gore), at 5.—C. S. Fox, and others: Discussion on Dr. Heron's Report on the Geology of the Mount Everest Region.

ARISTOTELIAN SOCIETY (at University of London Club, 21 Gower Street, W.C.1), at 8.—Dr. G. E. Moore, Prof. G. Dawes Hicks, and Miss L. S. Stebbing: Discussion on Dr. McTaggart's "Nature of Existence."

SURVEYORS' INSTITUTION, at 8.—R. Cobb: Agricultural Valuations.

TUESDAY, APRIL 11.

ROYAL SOCIETY OF MEDICINE (Therapeutics and Pharmacology Section), at 4.30.—Annual General Meeting.

ROYAL SOCIETY OF MEDICINE, at 5.—General Meeting.

INSTITUTION OF PETROLEUM TECHNOLOGISTS (at Royal Society of Arts), at 5.30.—A. Millar: Galicia and its Petroleum Industry.

ROYAL PHOTOGRAPHIC SOCIETY OF GREAT BRITAIN, at 7.—Dr. H. B. Goodwin: Photographic Portraiture, Pure and Simple.

QUEKETT MICROSCOPICAL CLUB, at 7.30.—J. Wilson: A Short Account of the Genus Closterium.—L. E. Brown: Imitative and Windowed Plants.

ROYAL ANTHROPOLOGICAL INSTITUTE, at 8.15.—Capt. T. A. Joyce: The Paquecha of Ancient Peru.—Miss A. C. Breton: Notes on Some Peruvian Antiquities.

ROYAL SOCIETY OF MEDICINE (Psychiatry Section), at 8.30.—Dr. B. Pierce: Recovery.

WEDNESDAY, APRIL 12.

ROYAL ASTRONOMICAL SOCIETY, at 5.—Major W. J. S. Lockyer: The Relationship between the Solar Prominences and the Corona.

GEOLOGICAL SOCIETY OF LONDON, at 5.30.—Prof. A. C. Seward: A Collection of Carboniferous Plants from Peru.—F. W. Edwards: Oligocene Mosquitoes in the British Museum, with a Summary of our present Knowledge concerning Fossil Culicidæ.—Miss M. E. J. Chandler: The Geological History of the Genus *Stratiotes*: an Account of the Evolutionary Changes which have occurred within the Genus during the Tertiary and Quaternary Eras.

INSTITUTION OF AUTOMOBILE ENGINEERS (at Institution of Mechanical Engineers), at 8.—A. F. Evans: Marine Engine Design as affected by Lifeboat Service Conditions.

ASSOCIATION OF ENGINEERS-IN-CHIEF (at St. Bride's Institute, Bride Lane, E.C.4), at 8.—W. H. Booth: The Artesian Wells and Geological Strata of London.

THURSDAY, APRIL 13.

OPTICAL SOCIETY (at Imperial College of Science and Technology), at 7.30.

FRIDAY, APRIL 14.

MALACOLOGICAL SOCIETY OF LONDON (at Linnean Society).

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