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## GEO-MORPHOLOGY.

*Lithogenesis der Gegenwart. Beobachtungen über die Bildung der Gesteine an der heutigen Erdoberfläche. Dritter Theil einer Einleitung in die Geologie als historische Wissenschaft.* By Johannes Walther. 8vo. pp. viii. + 535–1055. (Jena: G. Fischer, 1894.)

*Geotektonische Probleme.* By A. Rothpletz. 8vo. pp. 175. 107 figures, and 10 plates of sections. (Stuttgart: E. Schweizerbart, 1894.)

*Morphologie der Erdoberfläche.* By Dr. Albert Penck. Ratzel's "Bibliothek Geographischer Handbücher." 8vo. 2 vols. Vol. I. pp. xiv. + 171. 29 figures. Vol. II. pp. x. + 696. 38 figures. (Stuttgart: J. Engelmann, 1894.)

RECENT discussions in England as to the relations between geology and geography have only served to show that these sciences are so intimately associated that no satisfactory line of demarcation can be drawn between the two. These three works illustrate the extent to which this view has been accepted in the schools of Germany and Austria, and the valuable results to both sciences that follow from a due recognition of the fact. The three works agree in this, though they are very different in their aims and subject-matter. The first is a manual on rock-formation; the second, a monograph on one type of earth-movements; and the third, a systematic text-book of structural geography. One is a restatement of the principles of correlation, another a protest against speculation, and the other a compilation of the classifications of, and theories respecting, the different geographical forms. They have, however, so much in common in their methods, that they may be conveniently noticed together.

Prof. Walther's work goes even further. It shows not only the inseparability of geology and geography, but the need of a knowledge of biology for the correct application of the evidence of palæontology to stratigraphy. Since the days of William Smith, the evidence of fossils has been regarded as final in both historical and stratigraphical geology. It is therefore rather startling to find a geologist stating that the history of the earth could have been written from the structure of the rocks alone, without the assistance of the organic remains within them. It has been the rule, in the determination of the age of any particular bed, to accept only the evidence of the fossils as valid. So long as the method of correlation by the proportions of species and genera common to two horizons, was confined to comparatively simple areas, it gave fairly trustworthy results. But when extended beyond Britain and the North European plain, it was the cause of serious confusion. The classification of the very variable Cainozoic deposits of the Mediterranean basin were involved by it in chaos; it caused beds in Australia to be assigned to the highest instead of the lowest division of the Cainozoic, and led to limestones in the West Indies, probably formed in part within the historic period, being referred by high authorities to the Miocene. Even in such a simple sequence as that of England, the method led to errors, as, *e.g.*, in the exaggeration of the gaps in the geological record, such as that between the Chalk and the Lower London Tertiaries. Occasionally a warning against the neglect of lithology would be uttered, as by Godwin Austen and Sorby, or an effort made to use it. But the former were ignored; and the latter were not at first judicious, as in the case of the famous generalisation, that we are still living in the age of the Chalk, a suggestion about as useful as that we are still living in the Silurian, because sandbanks were formed then and are forming now.

For the recognition of the necessity for the limitation of palæontology, we have in the main to thank biology. Taxonomy—the study of distribution—has shown that age is only one of many conditions that govern the character of a fauna; the depth, the composition of the sea-floor, the distribution of the ocean currents, the proximity of different bathymetrical zones, all exercise an influence. Thus a fauna is often more allied to an extinct one, than to those which are living simultaneously in adjoining areas. Taxonomy has exercised its influence in two ways. In the first place, it has insisted on the proper recognition of the self-evident fact that deposits change in space as well as time; that a sandstone, *e.g.*, may change into a clay laterally as well as vertically. Thus it is now recognised that the dividing line between the Gault and the Upper Greensand is a varying lithological one, and that the latter formation in one area was formed at the same time as Gault was being laid down in another. In the second place, it has led to the adoption of more detailed, zonal stratigraphy, and the demonstration thereby, that adjacent beds of different composition, and containing different faunas, have often been deposited simultaneously in stratigraphical continuity.

These views have gradually worked their way into general recognition by geologists, but Walther's is probably the first text-book in which they have been adequately expressed. The inconvenience in map-making, and still more in map-reading, which they involve, has led, perhaps, to an unconscious bias against them. Hence, even when theoretically admitted, their guidance has not been accepted practically. Walther's "Geologie als historische Wissenschaft" is, however, saturated with the results of biological teaching, the influence of which we may trace in nearly every page of the "Lithogenesis." Though well skilled in palæontology, he does not attach an exaggerated importance to the evidence of this science, but seems even to tend to the other extreme: if he does not underrate its value, he at least protests that it is less indispensable than has been thought. In his ardour for lithology, he goes so far as to say (p. 538) that "if we had an exact phenomenology of rocks, we could, without fossils, from the rocks alone, read the history of the earth." Walther's work is an effort toward such a "phenomenology," by an exposition of the lines along which it may be attained. He defines (p. 537) the objects of lithogeny "as the elucidation of the development of the fossil rocks by the investigation of rock-forming processes now in operation." He urges that rocks should be studied from the same point of view as animals and plants. He thinks that in comparative lithology, ontogeny should hold the same place as it does in comparative morphology. This lithology he divides into three sections, equivalent to those adopted in biology. Thus, he says that the study of rock structure answers to comparative anatomy, the development of rocks now in process of formation to embryology, and petrography and stratigraphy to palæontology. Throughout the book he introduces biological terms and phylogenetic trees to emphasise his views. For example, he classifies rocks as homologous and analogous; as the former, he includes all those which are formed in the same "Facies-bezirke," and as the latter, those which are formed under different geographical climates. And climate, in the sense of this later-day lithology, is "the sum of all the meteorological and oceanographic conditions, including organic and inorganic processes," which affect the formation of a rock. The use, however, of these terms often appears of doubtful value; thus, when he states that the lavas of an oceanic island are only homologous with those of a continent, we doubt whether we are in any way better for the information.

The work is divided into three parts, entitled, respectively, "General Lithogeny," "the existing Facies-bezirke," and "the bases of Comparative Lithology." The first of these occupies fourteen chapters: it begins with an account of the destruction, deposition, and alteration of rocks. The destructive processes he divides into four classes: weathering, chemical, physical, and organic; ablation, both of ice and rock surfaces; transport; and corrasion. The last he restricts to the comparatively insignificant polishing action of loose material carried about by the wind, rivers, ice, or sea. According to Walther's scheme, denudation results from ablation, transport, and corrasion; he attributes it to four agencies, viz. the wind acting by "deflation," running water by "erosion," glacier ice by "exaration," and the sea by "abrasion." The second part of the book is the longest; each chapter is devoted to the description of a group of deposits, which he says are "homologous," as they are formed in the same "facies-bezirke" or geographical zone. Thus, on the continents there is the zone of the Polar Regions, with moraines, humus, ochre, &c.; the temperate zone, with its black earth, loess, &c.; the desert girdle, with its sand and salt deserts, and dried-up lake-basins; and the tropical zone, with its laterite and cotton soil, &c. Other groups of homologous rocks are the products of continental volcanoes, shore deposits and those of open seas, of oceanic abysses; coral reefs, and volcanic islands. Very obvious objections to this classification could be easily raised, and it certainly could not be recommended for the purposes of ordinary teaching; but as long as it is used only to illustrate the association of deposits, formed under any particular set of geographical conditions, it is extremely useful. The different subjects treated in the work are, moreover, brought well up to date. Thus, *e.g.*, in the account of the supposed iron-secreting organism *Gaillonella*, the latest botanical researches of Molisch are summarised, and its character left more doubtful than ever. The chapter on coral-reefs is especially well done. The sketch of the life of a reef (pp. 915–927), which he calls the "richest of bionomic assemblages," is the best we know. The definition (p. 909) of a coral reef as being essentially formed of branching corals, with calcareous sediment filling the interspaces, expresses a truth which is often overlooked. Even this is enlarged on another page, where it is stated that geologically a reef must be regarded as including not only the calcareous sediment on the surface, but that which is formed around it, to the depth of as much as 3000 metres. He illustrates the slopes around coral islands by the numerical method, due to Dietrich, which brings out clearly the differences between such atolls as those of the Bahamas and Keeling Island. The mean figures which he gives do not, however, teach much. It is interesting, therefore, considering that the coral island question is handled with full knowledge of all the latest information, and that the author's own investigations took place upon a region to which Darwin's theory was never intended to apply, to notice that he accepts that theory as substantially correct. It is surprising, considering the accuracy of the rest of the chapter, that a recent photograph of a *Pectinia quadrata* is again quoted (p. 899) as a *Manicina areolata*.

The third section of the work is that which enunciates the general conclusions. It contains short chapters on the correlation of facies, the equivalence of rocks, the changes in the facies of deposits, and the lithological significance of organisms. This part of the book is, however, the least satisfactory; perhaps because most useful originality had been expected in it. Variations from the ordinary method of treatment and overstrained analogies had been passed in the hope that they would be turned to some account. This part of the book is, however, so general in its treatment, that the conclusions are rather indefinite. Nevertheless, the work is throughout so novel in treatment, so up to date in its information, that this cannot seriously impair its value.

Rothpletz's "Geotektonische Probleme" is a very different work from either of the others. Its title is a little misleading; one might expect from it an account of earth-movements in general, and a discussion of the theories of earth-structure by which these may be explained. One is, therefore, a little startled at finding that it commences with a protest against theories, and a warning against the danger of ideas creeping into general acceptance, under cover of a convenient term. He points out, for example, that Suess's term of "horst" for a mountain mass formed of one block of material, is so useful in descriptive geology, that it has been widely adopted. Rothpletz fears, therefore, that Suess's theory of the origin of "horsts," and its corollary that horizontal beds are never uplifted, may be unconsciously accepted. Similarly he foresees that, by the adoption of other convenient terms, the whole heresy of "Suessism" may gradually work its way into a position of influence it would never attain by its merits. The perils to geological progress threatened by this insidious "hypothesis building phantasy," as Rothpletz calls it, he thinks can only be averted by the critic, whose duty it is to bring all hypotheses to the test of facts. And the author sets himself to perform this task. His volume is devoted to the class of earth-movements known as "overthrusts." When cases of the inversion and repetition of strata were first noticed, they were regarded as due to the folding of the beds. During recent years, many of these have been shown to be due to the thrusting of one set of beds on to another, either horizontally or at a low angle. Rothpletz shows that these overthrusts are even wider in their distribution than is now generally admitted. He describes the most important cases, summarises the literature and various theories regarding them, and states the explanation which seems to him to agree best with the facts. Most of the examples quoted, the author has personally examined.

The first case taken is that of the classical Linth in the Glarus. This, as interpreted by Escher and Heim, has exercised a great influence on geological thought. The valley has previously been regarded as due to a great double fold. Rothpletz, however, maintains that it is a "graben" or rift-valley, formed by the subsidence of the block of material which once filled it up. One difficulty that hitherto told against this explanation, was the fact that the marginal faults had never been discovered. Rothpletz, however, maintains that they are there; he describes them at one point, in a section which, he declares (p. 10), "must silence the most utterly sceptical." The denial of Heim's famous double fold necessitates a new interpretation of other features in the geology of the country. Thus the rocks in the Schild—the mountain to the west of the town of Glarus—have been explained by Heim as the crushed-out beds of the middle limb of the fold. Rothpletz, however, maintains—and his evidence seems conclusive—that they are due to an overthrust. He adds a further difficulty to Heim's theory, by showing that if true it is inadequate as it stands. The country is more complex than a double fold can explain; a treble and a quadruple fold at least must be assumed, for the beds repeat themselves more than thrice. This Rothpletz explains by the assumption of three overthrusts, which he names after Schild, Kapf, and Plattenalp.

The next case considered is that of the mountain mass of Sentis, to the north of the Glarus area. This was described by Escher von der Linth in 1857. It was then said to be remarkable in having a great series of faults crossing the axes of the folds, but none parallel to them. This was confirmed by the maps and memoirs of Escher's pupils, and Suess, therefore, in 1885, made the Sentis the type of a class of mountain structure named "Blätter." Some discrepancies between the descriptions and the maps led Rothpletz to re-examine the country. The result is that he finds numerous faults parallel to the ridges, as well as across them, and also a series of overthrusts which occurred later than the folding, and earlier than the transverse faults.

From the Sentis it is natural to turn to the Juras. This range has long been famous owing to the ingenious devices designed to enable the fold theory to account for the rock sequences that occur there. But the "vanishing trick" diagrams, by which the absence of certain beds has been explained, have always been viewed with suspicion; they seemed too much like the schemes by which Ptolemaic astronomy was reconciled with facts. Müller in 1860 demonstrated their insufficiency, but they still survive. Rothpletz discusses this fold theory in its three most plausible modifications, viz. the faulting of over-folds; the folding of an area after the rocks in the centre have been raised by a double fault; lateral contraction forcing one side of a valley of erosion over on to the other. Rothpletz dismisses these, and accepts the theory of overthrusts along slightly inclined thrust-planes.

The fifth case is that of the highlands of the north-west of Scotland. This is so well known, that the author adds nothing new, except a doubt as to the relation of the minor and major thrusts. He notes with relish the abandonment of the view at first announced that the thrust-planes started as a result of the inversion of overfolds.

A simple example of overthrusting in a much later geological period is afforded by the granite of Lausitz in Saxony, which occurs above the Turonian limestones. This superposition was explained at first by the chalk having been deposited under an overhanging cliff, and then by the granite having been dropped as an erratic. Both these theories were ridiculously inadequate. The most popular explanation assigned an eruptive origin to the granite; the absence of contact-alterations and of apophyses from the granite is fatal to this. Overthrusting is the only theory left, and this Rothpletz accepts as satisfactory. The earth-movements in the coal-fields of Westphalia, Belgium, and northern France are next considered; these have long been known to be extremely complex. The explanation now accepted, is summarised with great lucidity, and illustrated by over thirty figures and three plates of sections. It attributes the present structure of the country to the inthrusts of slices of complex composition between other deposits. The last case considered is that of the area of the coast of Provence and the French Alps. The author has not personally examined the ground, and so would have preferred not to discuss it. Haug, however, has suggested that the assumed "pli-failles" (or fold-faults) are often only inverse faults, and that the latter are capable of explaining the phenomena without the hypothetical folds. Rothpletz, therefore, thinks it advisable to discontinue the use of the word "pli-faille," and suggests the substitution of "faille de recouvrement," or some other term which does not beg the question.

In the concluding chapter, Rothpletz summarises the general characters of overthrusts. He remarks that their importance is being more widely recognised, and that they are accepted now in explanation of many phenomena for which the agency of folding was formerly invoked. He thinks that they probably always occur in mountain formation. He discusses their relations to the earth-movements with which they are associated, as far as our present knowledge enables these to be generalised. Thus, the thrust-planes occur approximately parallel to the folds, but the inclination of the planes is usually in the opposite direction to that of the mountains: this might have been expected, as it is in harmony with some of Daubree's experiments. Divergences between the strike of folds and overthrusts, however, occur, and are explicable by the later origin of the latter. The inclination of thrust-planes is almost always different from that of the beds or folds; the former, however, both above and below the thrust-plane, occur in their normal sequence. Friction breccias, mylonites, &c., occur along the thrust-plane, while "schleppung," or terminal curvature of the beds toward the plane, is generally developed. A single thrust-plane may occur; but, as a rule, there are many parallel to one another, and this results in the type named by Suess the "Schuppen-structure." The chapter concludes by a consideration of the classification of earth-movements, and its difficulties; that advanced by Suess, he recognises as the most important, but he does not admit it as at all satisfactory.

This shyness of classifications is in striking contrast to the attitude of the last work; in which all the types of "earth-forms" are classified in a detail, and with a terminology, which seems at first needlessly elaborate. The work is a systematic account of the orography or structural geography of the earth, and is quite unlike any existing text-book. It has taken more than ten years to prepare. The delay has been partly due to the enormous amount of literature that has had to be considered, but also to the fact that during this period two works have appeared which have completely changed the whole aspect of geographical science. These are Richthofen's "Führer fur Förschungsreisende," and Suess' "Antlitz der Erde." The former introduced a more scientific classification of "earth-forms" or geographic types, while the latter has revolutionised our ideas as to how those earth-forms have been developed. One of the great advantages of Prof. Penck's work is that it is a re-description of the earth's surface in the terminology and in accordance with the views of these two leaders of geographical thought. It is a book which it is impossible to summarise. It is a compilation showing on every page the most detailed care and accuracy. No one acquainted with Prof. Penck's previous writings will be surprised at his extensive knowledge of the literature of both geography and physical geology. The numerous historical summaries that occur in it, show how thoroughly the author has ransacked literature, and how well the book has been brought up to date. Works published so late in 1894 as that containing Heim's description of the Pleistocene earth-movements in the Alps ("Die Enstehung der Alpinen Randseen"), and Günther's memoir on the influence of atmospheric pressure on isostacy, are included. It is only natural that English literature is not so thoroughly done as the German, but important omissions are surprisingly few. The two most important are probably the absence of reference to Whymper's work on aneroids, from the chapter on altitude determinations, and to C. Reid's explanation of the formation of the chalk coombes, from the discussion of the origin of dry valleys.

The work is divided into three parts, dealing respectively with general morphology, the surface of the earth, and the sea. Its plan is based on the conception of the earth's surface as composed of a series of "earth-forms" which range between the extremes of mountains and valleys. The description and classification of these, and the study of their origin and development, form the subject-matter of geographical morphology. This science, therefore, depends on the literature of geodesy, geology, and geography. The book commences with an outline of general morphology, which depends in the main on the first of these. The chapters on mathematical geography, and on morphography and morphometry, are probably the most valuable of the five devoted to this part of the subject. In these he states the latest conclusions upon various debated problems. He points out (p. 9) that the amount to which the form of the earth deviates from an ellipsoid of revolution is between ± 200 and ± 250 m. He discusses the relative value of the various geoids, and expresses a preference for Northern Europe, for Bessel's instead of Clarke's, which is used in England. The principles of earth-measurement are briefly considered; the standard levels used in different countries are tabulated, and their relations to each other shown. The value and method of construction of hysographic, klinographic, hypsoklinographic, and bathygraphic curves are shown. The difficulties in the determination of altitudes caused by the uncertainties of refraction are pointed out. The inevitable inaccuracy of map lines is illustrated by a list of the lengths assigned to a portion of the Istrian coast in a series of standard maps; the figures range from 105 km. to 223·81 km. The calculation of the volumes of continents is considered, and finally elaborate tables given of geographical statistics. The ratio of land to water is taken as 2·54 (p. 97); the principal previous estimates are given from the time of Riccioli, who in 1661 estimated that the land was in excess in the proportion of 8 to 5. An interesting sketch of the literature on "geographical homologies" shows how early attention was drawn to the remarkable parallels and contrasts in the distribution of land and water. This part of the work concludes with the consideration of the question of the permanence of oceans and continents. Penck quotes Cayeux as if this author's investigations proved the terrigenous origin of all the chalk, and though he notices Blanford's arguments, he does not seem to appreciate their full significance. His sketch of the literature of the subject shows that, though with some striking exceptions, the difference on this question has been one between geologists on one side, and geographers on the other. In this connection it is interesting to note that Penck accepts (p. 167) the view that the ocean floors have a higher specific gravity than the continents, and places the difference, according to Helmert's work, at ·001 of the specific gravity.

The second part of the book describes the surface of the earth, or the "Landoberflache." The first section of this deals with the composition of the earth's crust, and the forces that act upon it. The figures given to illustrate Suess' terms are very clear and instructive; the table of geological systems is, however, out of date; the Ordovician is not accepted, and the Tertiary and Quaternary are each regarded as equal to such divisions as the Trias and Permian. The account of the agents of denudation is very detailed and thorough. The hydraulics of river action (pp. 259-385) is treated with especial care, and the references to the literature of the subject include a much wider range than is usual. The controversy as to Baer's law of the influence of the earth's rotation on the direction of rivers is clearly summarised, and the truth of the law upheld; great stress is laid upon the deepening of the Rhine on its left bank in the regulated portions of its course. The author attributes to glaciers considerable erosive power; he maintains that the characteristic feature in erosion by ice, is that the excavations vary in depth with the strength of the rocks, so that true rock basins are formed (p. 409). He still accepts the glacial origin of cirques, and even approves of Ramsey's views of the origin of some of the Alpine lakes. The description of the existing "earth-forms," or geographic types, occupies the first 460 pages of the second volume. These "earth-forms" are divided into eight types—plains, heaped-up mounds, such as moraines and dunes, valleys and the highlands through which they run, basins, mountains, areas of subsidence, and finally fissures and caves. The characters, classification, method of formation and terminology, including both local and scientific names, are stated in detail. A sketch of the literature of each type is also given. The chapters on "Wannen" or basins, and on mountains, are probably the best. The book closes with an account of the oceans, and the deposits on their floors.

The one serious drawback to this book is its complete neglect of the evidence of zoological distribution. Thus, for example, the questions of the origin of the Caspian Sea and the lakes of Nicaragua, are fully considered, but no reference is made to their faunas. No theory, however, could be accepted which failed to account for the anomalous characters of these. But it would be too much to expect Prof. Penck to show the same mastery of the literature of biology as he does of geography and geology. In this respect, Walther's book is superior to that of Penck. But it is idle to estimate their respective merits, for the three works are so different. One cannot compare Walther's statements of the principles of correlation with Rothpletz's detailed mapping, and either with Penck's digest of literature. Penck's, however, will probably prove the most generally useful of the three. An English translation would be of great service, by calling attention to a branch of geography that has been unaccountably neglected in this country. Thus, in the Geographical Society's "Hints to Travellers," instead of the details of Richthofen's "Führer," the subject is not even mentioned. A translation would, moreover, necessitate greater precision in the definition of geographical terms, and the introduction of many new ones, for which there are now no equivalents in English, and which are essential to the scientific treatment of geography.

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## ORGANIC CHEMISTRY.

*The Rise and Development of Organic Chemistry.* By Carl Schorlemmer, LL.D., F.R.S. Revised edition, edited by Arthur Smithells, B.Sc., Professor of Chemistry in the Yorkshire College, Leeds. (London: Macmillan and Co., 1894.)

FOR some time this excellent historical survey of the development of organic chemistry has been out of print, and students of chemistry will heartily welcome the appearance of a second edition, which has been extended, in order to include a review of the more important results of the original investigation of the last ten to fifteen years.

Facing the title-page is an exceedingly good likeness of Schorlemmer, admirably reproduced from a photograph; then follows a short biographical notice, giving a brief sketch of the author's career, in which his brilliant researches are described. This is a very welcome addition to the book, because, as the editor points out, Schorlemmer, with characteristic modesty, mentions these researches only on two occasions in the book (pp. 141 and 197), and then but very briefly.

Chapters i. to v. are very much the same as in the first edition, only a few slight alterations having been made. Chapter vi. deals with the perfection of the methods of organic analysis by Liebig, and these important researches, which affected in such a marked manner the subsequent development of organic chemistry, are perhaps scarcely discussed at sufficient length; a more detailed account of the history of organic analysis is to be found in Roscoe and Schorlemmer's "Treatise of Chemistry" (vol. iii. p. 40). This chapter vi. also contains a short sketch of the work which led to the discovery by Raoult of his well-known method of determining the molecular weight known as the cryoscopic method.

Chapters vii. and viii. have not been much altered, but chapter ix., which deals with the constitution of benzene, tautomerism, and the asymmetric carbon atom, has, as was to be expected, been largely added to, and made to embrace most of the important results of recent work.

The constitution of benzene is dealt with in a very interesting manner. Baeyer's researches, on succinosuccinic ester, which led to the rejection of Ladenburg's prism formula, are discussed, as well as those of Bamberger, on the reduction of naphthalene derivatives, the results of which may be said to have completely confirmed Baeyer's views.

After a short description of Laar's tautomeric hypothesis, the remainder of the chapter is taken up with Le Bel and van't Hoff's theory of the asymmetric carbon atom, and with Wislicenus' development of this theory. In a future edition, more emphasis might, perhaps, with advantage be laid on the general applicability of these theories, so that the student may not receive the impression that they have only been found valuable in the explanation of isolated cases, as, for example, the isomerism of the malic and tartaric acids, and of fumaric and maleïc acids.

The first part of chapter x. is devoted, principally, to the history of organic synthesis, and contains an account of Frankland and Duppa's work on aceto-acetic ester, and of Conrad's researches on malonic ester, showing the value of these ethereal salts in synthetical work. The synthesis of malic, tartaric, and citric acid is also mentioned.

A very valuable historical sketch of the chemistry of the sugars, including a clear exposition of the more important results of E. Fischer's classical researches, followed by an account of Ladenburg's synthesis of coniine, and of the synthesis of uric acid, by Horbaczewski, concludes this excellent chapter.

The remainder of the book does not differ materially from the first edition, except that a very good index of authors' names and subjects has been added.

Students of organic chemistry must always be interested in the development of the science, and to them this work will be cordially welcome. It is a thoroughly readable book, written throughout in an attractive manner, and comprising in one small volume all the facts necessary for understanding the growth of organic chemistry.

Schorlemmer wrote, whenever possible, in German, and never had any real facility in writing English. The editor is, therefore, to be congratulated on the very satisfactory manner in which he has performed the difficult task of preparing this book for the press. Great care has evidently been taken in reading the proof-sheets, as we have only noticed one or two unimportant misprints.

## OUR BOOK SHELF.

*British Birds: being Coloured Illustrations of all the Species of Passerine Birds resident in the British Isles, with some Notes in reference to their Plumage.* By Claude W. Wyatt. 4to. Pp. iv. 25. (London: William Wesley and Son, 1894.)

THE author is a well-known ornithologist, who has made two expeditions, of which the results have been published—one to the Peninsula of Sinai, and the other to the Magdalena Valley in Colombia—and these proved that he was not only a good collector, but also a keen field-naturalist. He then travelled extensively, and visited many parts of the globe, observing the habits of birds, and making sketches of every kind of scenery. The latter became a great feature in the plates of the "Monograph of the Swallows (Hirundinidæ)," which he brought out in conjunction with Dr. Bowdler Sharpe, who contributed the letterpress of the work, while Mr. Wyatt drew all the plates.

The present volume is the first of two which the author proposes to publish, the one before us dealing merely with the resident Passeres of the British Islands, while the second is to contain figures of all the migratory Passeres, the Picarian birds, the birds of prey, and the pigeons; but the game birds, waders, and swimming birds will be, presumably, treated of at a future period. Fifty species are illustrated by Mr. Wyatt in his first volume, and occupy twenty-five plates. As with his pictures of the swallows, the author makes a great feature of his accessories, and some of the landscapes are very pretty, and are evidently drawn from nature. The attitudes of the birds are life-like, and some of them are exceptionally good, the crows alone striking us as failing in massiveness of bill. The letterpress is of the simplest, and would have been all the better for more complete references to standard works, as many of those given are incorrectly quoted. It is, however, more as an artist than as a writer that Mr. Wyatt shines, and he is to be congratulated on having produced a very handsome volume, with beautifully coloured pictures of some of our most familiar favourites. As regards quality of paper, printing, colouring, and binding, there is nothing left to be desired.

*Standard Methods in Physics and Electricity Criticised, and a Test for Electric Meters Proposed.* By H. A. Naber. (Published by the Author, 1894.)

FROM the title and table of contents of this work, one would expect to find a treatise on experimental physics. This expectation is, however, rudely dispelled when one commences to examine the letterpress. After a very brief description of the form of gas voltameter which the author has devised (see NATURE, July 12, 1894), more than a hundred pages are devoted to what presumably the author considers an exhaustive examination of the different uses to which this voltameter may be put. The fact that his *voltameter* has a considerable resistance, causes the author considerable trouble, but he consoles himself with the reflection that a Cardew or other *voltmeter* generally has a resistance of from 100 to 900 ohms. The difficulties encountered in measuring a quantity of electricity by copper or silver deposition are dwelt upon, and a new objection is raised, namely, that since the deposits have to be weighed, variations in gravity will affect the results! At another part of the book the ordinary balance is considered devoid of sufficient accuracy, since the arms have generally different lengths, and Nicholson's hydrometer is recommended as a substitute when great accuracy is desired. In a chapter on sound, the author strongly recommends bicycle-wheels as a motive power. Apparently the cycle-wheels are to set themselves in motion, since the idea of driving any piece of machinery "by hand" is derided, and the great waste which takes place when water and other motors are used, is dwelt upon as a reason for their abandonment. One has met with the library steps which can be converted into half a dozen other articles of furniture; but these old friends sink into complete insignificance when compared with this gas voltameter and the numerous uses claimed for it, such as blowing soap-bubbles full of oxygen and hydrogen, which on being exploded can be used as fog-horns; supplying oxygen to aëronauts, or to explorers in coal-pits after an explosion; and preparing chlorine. It can also, we are told, be used as a barometer, pyknometer, ice calorimeter, dylatometer, thermostat, hygrometer, anemometer, level, or for exhausting incandescent lamp bulbs. The above are a few of the uses claimed, and are extracted from what the author describes as not an "exhaustive list"! W. W.

*Electrical Engineering, for Electric Light Artisans and Students.* By W. Slingo and A. Brooker. Pp. 740. New and revised edition. (London: Longmans, Green, and Co., 1895.)

AN admirable work, covering the whole field of electric lighting. Though designed to include those branches of the subject prescribed in the syllabus issued by the City and Guilds Technical Institute, its scope is such as "to make it embrace the requirements, not only of those actually employed in the electric lighting industry, but also of those who, while having little or no electrical knowledge, have under their supervision various kinds of electrical machinery." The book is not merely a descriptive catalogue of electrical machinery, like some that we know, but a clearly-written, and amply-illustrated, volume which has proved of great service to engineers during the past five years, and, in its revised form, is sure to hold its own in the future.

*Lens-Work for Amateurs.* By Henry Orford. Pp. 231. (London: Whittaker and Co., 1895.)

A LENS is defined in this volume as "a portion of a refracting medium . . . bounded by two spherical surfaces which have a common axis." In the following paragraph, lenses with one of their surfaces plane, are described; wherefore we would ask Mr. Orford, why he did not include these in his definition? This, however, is but a detail. As a whole, the book is a trustworthy guide to the manufacture of lenses, suitable alike for the amateur and the young workman. It is profusely, though rather coarsely, illustrated by diagrams, and the instructions are simple and practical.

*Manual of Practical Morbid Anatomy.* By H. D. Rolleston, M.A., M.D., F.R.C.P., and A. A. Kanthack, M.D., F.R.C.P. Pp. 240. (Cambridge: University Press, 1894.)

A PRACTICAL handbook for the post-mortem room, showing how to carry out a systematic examination of a body, and indicating what morbid changes should be looked for.

## 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.*]

### A New Step in Statistical Science.

CONTRIBUTIONS of an abstract kind to statistical science are so little read by the bulk of statisticians, that the scope of the remarkable memoir by Prof. Karl Pearson may be unappreciated by them unless attention is pointedly directed to it.[1]

Statisticians are conversant with the use of curves to epitomise masses of data. The forms of the majority of these curves are skewed or humped, and have hitherto been nondescript, except as Prof. K. Pearson's previous memoir showed, some of them may be dissected into two or more normal curves, having different constants. It is only a few curves that are symmetrical and conform closely to the normal law of facility of error. These few have been much studied, the numerous and valuable properties of the normal curve being extremely helpful in dealing with them. When the conformity between the observations and the normal law ceases to be close, the latter must be applied warily. When the discrepancy is serious, it becomes unsafe to trust the theory at all. Not a few statisticians have chafed under these limitations, and felt that the normal law is too limited in its grasp to satisfy their needs. Now at length, it turns out, thanks to Prof. K. Pearson, that the normal law admits of being regarded as nothing more than a very special case of a highly generalised theory, by whose aid curves may be drawn that shall fit every one of the observed curves he has tried as yet. The shapes of these are curiously varied. Their list includes the dimensions of shrimps and prawns, of American recruits and of school-girls, of Bavarian skulls, of frequency of enteric fever, and of divorces, of variation in house value, in butter-cups and in clover, in pauper percentages and in a mortality curve. Only those who have studied the delicate and oddly-shaped drawings of these observed curves on a large scale, upon which the equally delicate *fitted* curves have been superimposed, can adequately appreciate the wonderful closeness between the pairs of outlines. There can be no doubt that the descriptive efficiency of Prof. Karl Pearson's method is of the highest order.

The question of the utility of the method to ordinary statisticians has now to be considered. First, as to its descriptive powers. We are already able to describe the whole of any normal series by means of only two numbers; say, by the average of all the members of the series, and by the mean of the several departures of its individual members from that average. Henceforth, by the use of more constants, we shall be able to do the same to any series. A few figures will always serve as the equivalents of a vast amount of tabular matter.

The second and higher use is to afford a clue to the cause or causes of variety. It has long been a dream to me to select a peculiar and often recurring form of curve, and to study with all possible care the conditions under which it has been produced, so that whenever a new curve of that same form was met with, there should exist some guidance towards discovering the cause of its production. I have made not a few attempts from time to time, but was discouraged by the then impossibility of sufficiently defining the curves that were dealt with. That difficulty seems now removed. To explain myself further, let us suppose that a man finds the mark of a more or less incomplete circle on the ground, and wishes to discover how it was made. Various possibilities exist, which might have been recorded to help him: (1) The mark may have been made by a basin, &c., turned in a lathe, or, what come to the same thing in principle, by something revolving round a fixed centre. (2) It may have been stamped by a hoop, formed by bending an elastic rod until its ends met, the circular form depending on the equal distribution of stress. (3) It may have been the mark of a withy that had bound a faggot, which, after setting into shape, had broken away, the circular form arising from the compression of the sticks of the faggot within the smallest possible girth. (4) It may have been the mark of a warped sheet of bark, hide, &c., the circular form of which depended on the unequal contraction of its outer and inner layers. (5) It could have been made by a projecting nail, near the angle formed by two straight rods securely joined at one end; the apparatus being caused to straddle and press upon two pegs in the ground, and moved in the only way possible under those conditions. Here the fragment of a circle would be due to the constancy of the angle subtended by the same chord. A catalogue of these and other possibilities, which are numerous and include circular forms of animal and vegetable growth, would certainly enlarge the speculations of the observer as to the cause of the circular mark. So it would be with the curves of which I spoke. Each form of curve would be a serious study in itself; still the results would gradually accumulate, and it is reasonable to look forward to a time when a set of such curves, each defined by Prof. K. Pearson's, method, shall have been studied.

I venture upon one criticism as to the completeness of his generalisation. Variation of the normal kind is supposed to be due to the combined effect of (1) an infinite number of causes, that are (2) equally likely to err in excess or deficiency, and (3) that are independent of one another. These three restrictions are removed in the generalised curve, which bears a certain relation to the binomial point curve formed by the expansion of $(p+q)^n$ when (1) $n$ need not be infinite, (2) $p$ need not be equal to $q$, while (3) the binomial form which implies independence of the contributory causes, is modified. Now though the condition (3) is removed, it does not, as yet seem to me that the supposition which replaces it, and which is based on such considerations as the effect of withdrawing $r$ cards from a pack of $ns$ cards containing $s$ suits, is analogous to what commonly occurs in *rerum naturâ*. Namely, the intermingling of contributory causes of various degrees of efficiency, some of which are very few in number and have large effects. Thus the number of persons who walk day by day down St. James' Street, is occasionally vastly augmented by some national spectacle, and it is considerably and irregularly affected by changes in the weather. It does not wholly depend on a multitude of equipotent causes. So again, the time of ripening of the fruit on a tree generally, is much affected by the aspects of the particular branches on which it grows. I therefore conclude that the effects of an aggregate of large and small causes, ought to be distinctly included in a thoroughly generalised formula of variation.

FRANCIS GALTON.

[1] "Mathematical Contributions to the Theory of Evolution" (Part ii.), by Karl Pearson. Read at the Royal Society, January 24, 1895.

### The Kinetic Theory of Gases.

I THINK sufficient stress has not been laid on the distinction between the *purely mathematical* proof of the fundamental determinantal relation connecting the differentials of the coordinates and momenta of dynamical systems and the *purely statistical* applications of that relation which form the subject of the Kinetic Theory.

The well-known determinantal equation is perfectly general and applicable to any dynamical system whatever. It merely asserts that if the initial coordinates and momenta receive any small independent variations whatever, the resulting variations in the final coordinates and momenta after any fixed interval of time are so related to them that the differential product of the former variations is equal to that of the latter, conformably to the well-known laws of Jacobians, by which the variables are changed in a multiple differential or integral.

In general the variations in question are *purely hypothetical*, just as, in the principle of Least Action, the actual motion is compared with varied motions which have no real existence. If, for example, we consider the system to be the Earth, the variations could only be made real by making the Earth move differently to what it actually moves, and doing this in every possible way.

*But when it is required to assign any physical meaning to the determinantal relation*, these hypothetically varied motions must be represented by actual motions, and this can only be done by taking an indefinitely large number of independent systems, all similar to the one we started with, and setting them moving in all possible ways. The determinantal relation then tells us that if the coordinates and momenta of these systems are initially distributed according to what in my Report I have called the Boltzmann-Maxwell distribution, they will be so distributed at any subsequent instant. But in the absence of collisions or encounters between the system, this distribution will *not* be unique. There exist other distributions equally well satisfying the condition of permanence.

The case of two or more molecules of gas in the process of encounter can be deduced, as shown in my Report (§ 30), by taking each "system" to represent a pair of molecules, there being at every instant an indefinitely large number of such pairs having different coordinates and momenta. It now seems definitely settled that if the molecules are rigid bodies, the only possible permanent distribution unaffected by encounters is the Boltzmann-Maxwell distribution combined with motions of pure translation and pure rotation of the mass of gas as a whole (Report, § 46).

Many writers have limited their investigations to the case where all the encounters are binary, and I see that Prof. Fitzgerald has emphasised this point in his recent letter. I do not think this is the right place to draw the line. I can see no difficulty in taking account of encounters between three, four, or more molecules, provided that such encounters are sufficiently numerous to have a law of distribution. Where the line must be drawn is indicated in my Report, § 30 (iii.). The molecules which act on one another in any one encounter must form an infinitesimal fraction of the whole mass of gas, or the gas must at any instant be divisible into an infinitely large number of independent molecules and groups of molecules, each molecule or group thus constituting for the time being a free system by itself. When the molecules act on each other at all distances, or it is impossible to divide them into small independent groups, the whole of our theory breaks down.

It is this limitation which, to my mind, precludes our applying the Kinetic Theory in its present state, *not only* to molecules moving about in a continuous medium, such as the ether may be, but *also* to solids and, probably, liquids.

A good deal of confusion has, I fear, arisen with regard to what I have called Maxwell's Law of Partition of Kinetic Energy, *i.e.* the statement that "if the kinetic energy of a system be expressed as a sum of squares, the mean values of these squares are equal," from the fact that the term "*mean value*" may be taken to represent "time average for a single system"; and I fancy this may be the point Prof. Fitzgerald had in view when he asked if the conclusions would not apply to the Earth or a "finite number of particles moving about for an indefinitely long time." It cannot be too strongly emphasised that this interpretation of mean values involves assumptions which have hardly been sufficiently justified in any general class of cases, and which have been repeatedly proved to be invalid in simple cases (Report, §§ 9–12).[1] To give a simple (if not quite analogous) illustration: suppose that on drawing counters out of a bag, we were to obtain on the average an equal number of red, white, and green counters. We should *not* be justified in inferring that if we kept a single counter sufficiently long it would change colour and become in turn red, white, and green.

As an illustration of a case where the Boltzmann-Maxwell Law is inapplicable, consider a sphere of density $\sigma$ moving in a perfect liquid of density $\rho$. The kinetic energies of the sphere and liquid are in the ratio of $\sigma : \frac{1}{2}\rho$, as we know from hydrodynamical considerations, and the same is true for any number of spheres whose distances apart are very large compared with their radii. This is not a case where *no* transference of energy takes place between the sphere and liquid, and it is not therefore open to Prof. Fitzgerald's objection to the case I previously cited. Whenever the motion of the solid is varied, energy *is* transferred to or from the liquid.

If a *gaseous* ether will satisfy the requirements of physicists, then the Boltzmann-Maxwell Law is undoubtedly applicable to the ether. If not, the ether falls entirely beyond the scope of our investigation. The Kinetic Theory is obviously a theory framed to account for one class of physical phenomena only, viz. the thermal properties of gases. If any observed phenomena are not deducible from the results of the theory, it is to my mind sufficient to show that this is because the fundamental assumptions of the theory are not satisfied, *i.e.* that the phenomena in question are *not inconsistent* with the Kinetic Theory. G. H. Bryan.

Peterhouse, Cambridge, January 16.

[1] See also Nature, January 10, p. 262.

### Boltzmann's Minimum Function.

I said in my first letter on this subject that the condition A, on which, or its equivalent, the proof is based, could not apply to the reversed motion. As that assertion has been questioned, may I confirm it thus?

The initial distribution of R, the relative velocity, *i.e.* the number of pairs of spheres for which it has given direction, is arbitrary—condition A is fulfilled. Then, as proved, whatever the initial distribution, after collisions, the distribution of R is uniform, *i.e.* all directions equally probable. Now reverse the velocities. If condition A is fulfilled in the reversed motion, then after the reversed collisions the distribution of R is uniform. It is equally certain that it must be the same as the initial distribution.

If, therefore, condition A is fulfilled in the reverse motion as well as in the direct, that can only be because the distribution of R was uniform to begin with. But that means that H was minimum to begin with, and therefore $\frac{dH}{dt} = 0$ throughout.

Boltzmann's theorem can be applied to both motions only on condition that it has no effect in either.

1 New-square, Lincoln's Inn. S. H. Burbury.

### Electroscopes in Lecture.

I suppose teachers still use gold-leaf electroscopes for their junior lectures; certainly I have found nothing else so dead-beat, or so readily understood; and by projecting with a lens a shadow of the leaves on a square-foot translucent screen, the movements are perfectly visible to a large audience by daylight. But the one objection to the instrument, when used for explaining the fundamental facts, say, of induction, is that it indicates similarly positive and negative potentials. Yesterday, however, my assistant, Mr. E. E. Robinson, ingeniously stood the metal-cased instrument on a cake of paraffin wax, and electrified its outside negatively. By this process the zero of deflection is changed; the leaves stand apart for zero potential, diverge more for positive, and collapse for negative. A zero shadow-pointer and rough scale may be readily used; and I propose now to mount a projection electroscope in a suitable slightly-charged Leyden jar, whose outer coat can then be treated as the usual earthed terminal of the instrument, whose case is connected to or formed by the inner coat of the jar. The insulated or variable terminal is conveniently arranged as an insulated sphere or other shaped body on the lecture table, not far from the small screen, attached by a long enough thin wire to the leaves—of which it is perhaps best to have only one movable. Oliver J. Lodge.

January 25.

### The Perseid Meteors.

Your interesting reference (Nature, January 24, p. 301) to Dr. Bredichin's investigation of the Perseid shower, induces me to offer one or two remarks on the subject. In the paragraph alluded to, it is stated that the radiant was observed from July 22 to September 12, 1893; but this long duration cannot possibly refer to the same system as that which furnishes the abundant maximum on August 10. It is true there are radiants in Perseus in September, and the succeeding months of October, November, and December supply many others, but, after the end of the third week in August, nothing is seen of the real Perseids. I cannot say exactly on how many nights the display continues active, but it is certainly visible from July 19 to August 18, and the diurnal motion of the radiant is about 1° to the E.N.E.

There are really very few of the true Perseids seen after August 12, for the shower dies rapidly away after the maximum. On August 15, 1893, during a watch of three hours, I saw only one Perseid. On August 16, 1893, during a watch of $4\frac{1}{2}$ hours, I noted only four Perseids. I mention these facts to prove the extreme tenuity of the stream at the middle of August. But there are differences from year to year. An observer watching the heavens for a similar interval on the same dates in succeeding years will get a varied experience. Thus one year cannot be regarded as the criterion of all.

Some years ago I recorded a few swift streak-leaving meteors between August 19 and 24, from a radiant at 78° + 56° on the northern borders of Auriga, and supposed they might be late

Perseids, but subsequent observations have convinced me that they had no relation with the great August shower. They probably formed the early members of a well-defined radiant of September Aurigids which I found at 76° + 56° in 1879, and at 77° + 57° in 1885.

It appears to me that observations of the Perseids, and of other meteor showers, are often undertaken and discussed while losing sight of a most important circumstance. I refer to the necessity of thorough training on the part of the observer, before he can possibly hope to attain a high degree of precision in recording meteor paths. Many months, if not years, of diligent practice are required to render the observer proficient, and even then there are many students who, being deficient in natural aptitude, will never succeed in the work. It seems to be the fashion at certain observatories to set a number of observers (some of whom have perhaps never registered a meteor path before) watching and recording meteors, and then to investigate their results as though they could be thoroughly depended upon. Such results are, however, practically useless when employed to test any complicated point in meteoric astronomy. It is similar to placing a man, who has never played in a cricket match before, as wicket-keeper to fast bowlers like Mold, Richardson, and Woods, and expect his performance to be creditable! In meteoric astronomy, as in many other spheres of action, skill is only to be acquired by long practice; indeed, it is difficult to single out any other branch of observation where the eye and the judgment have to be so quickly and accurately brought into play to afford the best results. W. F. DENNING.

Bristol, January 27.

## The Artificial Spectrum Top.

IN the interesting letters on the above subject, which have recently appeared in NATURE, there does not seem to have been any reference to the experiments of Helmholtz, as described in his "Handbuch der Physiologischen Optik," 1866, § 23. He describes the facts in minute detail, and illustrates them with numerous diagrams.

One important point not yet referred to, and described in detail by Helmholtz, is that if a disc, marked with black and white sections, be rotated with a certain rapidity, the field appears to be covered with a pattern composed of hexagonal spots; at the part of the field of vision corresponding to the yellow spot, a transverse oval figure is seen. In the centre of this figure is a dark spot surrounded by a black circle.

Each of the hexagonal spots is dark with a lighter spot in the centre, and surrounded by a red thread, which appears to be moving in minute drops. The field seems to be pervaded by a greenish hue, which flows towards the yellow spot.

These experiments, which I have verified on every point, have a very important bearing on the photo-chemistry of the retina and on colour vision.

Hendon, January 26. F. W. EDRIDGE-GREEN.

IN reference to your Belfast correspondents' interesting experiments with the artificial spectrum, which were long ago included in my own experiments, a little reflection will show that when the speed of rotation is increased, we do *not* retain unaltered the resultant proportion of stimulus and anti-stimulus on the retina. With a slow rotation we have simultaneously on the retina a persistence image of the lines and a real image of the white card. When the speed is greater, we get simultaneously these two, and in addition a persistence image of the white card. Hence, according to my theory, the rise in scale with increased rapidity of revolution.

Colchester, January 26. CHARLES E. BENHAM.

## Snake Cannibalism.

THE reading of a paragraph and a letter printed in the *Mail* for October 24 and 29, reminds me of a case of one snake swallowing another, the consequences of which I witnessed. While engaged in running a survey line for a railway across a wood in this district, I noticed a snake close to me, doing its best to get out of my way, but almost unable to do so. One of my men struck at its neck with his "macheti," and succeeded in cutting the snake's head clean off. Immediately, to our great surprise, another snake of the same species slowly emerged head first, and, after a few struggles to escape, remained motionless on the ground; a gash in its cranium, which had been cut by the same stroke that killed the larger snake, being, no doubt, the cause of death, as the body was otherwise intact. A measuring tape showed that the larger snake was 6 feet in length, and the smaller 5 feet. In this case the snake was swallowed tail first, and therefore it seems highly probable that the larger snake simply devoured it, and did not commence by trying to dispute a portion of food, such as the pigeon and frog cited in other instances. H. TSNAGAL.

Sancti Spiritue, Cuba, November 23, 1894.

## More about Moths.

(*Communicated by Prof. S. Garman, of the Museum of Comparative Zoology, Cambridge, U.S.A.*)

IN NATURE for December 6, 1894 (p. 127), Mr. Henry Cecil publishes a criticism on a previous letter of mine, which I cannot accept without a few words of remonstrance. His explanation may be correct in part, but it certainly does not cover all the ground.

That resistance alone is not necessary for the expansion of the wings of moths, may be inferred from the fact that they will often expand after an interval of several days, when the moths have been prematurely released, the irregularity in outline arising, I think, from the evaporation of moisture from the wings, and in the consequent loss of elasticity. If the newly-hatched insects are confined in a warm moist box, this trouble seems to be obviated in a large degree, and the wings occasionally attain to nearly the normal dimensions.

In raising moths artificially, it cannot be assumed that the lack of proper pressure is entirely responsible for the frequent occurrence of cripples.

All the conditions of feeding, moisture, and heat, must first be carefully considered, since departures from the normal, on any one of these lines, might so lower the vitality of the insect, that perfect development would become impossible.

The writer also speaks of the wings of the moth in the cocoon as "folded and crumpled," a statement which is entirely at variance with my own observations. In all the cases which I have noticed, the wings are perfectly smooth and unfolded from the first, the increase in size resulting from a true expansion, the nature of which has, so far as I know, never been fully explained. L. C. JONES.

Melrose, Massachusetts.

## *THE PHYSICAL SOCIETY'S ABSTRACTS OF PHYSICAL PAPERS FROM FOREIGN SOURCES.*

THE days when learning meant dead languages, and science meant collecting beetles, have passed away; science has grown and spread until it is impossible for the most comprehensive intellect to grasp more than a few twigs on its numerous branches. Organised specialisation has become necessary to scientific progress. Each subject now has its special society, and each society has as much as it can do. Every sort of time-saving arrangement is necessary if the workers in any one branch of knowledge are to be kept informed as to what others are doing.

English chemists have long been supplied by the Chemical Society with excellent abstracts of the current literature of their subject, but up to the present the only available work of the same kind on Physics has been the *Beiblätter* of *Wiedemann's Annalen*. Admirable as these are, it is impossible that a German periodical can fully meet the wants of Anglo-Saxon physicists. It is therefore most desirable that abstracts of physical papers should be published in English. The Physical Society has now set itself to supply this want, and the first number of the new volume of "Abstracts" appeared early in the present month. The *Proceedings* of the Society will in future be issued monthly, and the abstracts of foreign papers on physics will be included under the same cover. They will, however, be paged separately, so that they can be bound separately at the end of the year, when full indices, both to the subjects and the names of authors, will be added. At present the *Proceedings* contain approximately fifty pages of original matter, and fifty pages of abstracts from foreign and American sources.

It is an open secret that it is intended to enlarge the abstracts later, so as to include English work. They will then be an epitome of the work done in physics throughout the world. The preparation of a large number of abstracts on all sorts of subjects involves a great deal of work and some organisation, and it is thus better to be content with abstracts of half the extent of those of the Chemical Society or the *Beiblätter* at first, at any rate. The financial risk is also very heavy for a society which is not rich, however energetic it may be. The British Association has come forward with a helping hand, and is aiding the Physical Society with a very considerable money grant.

Mr. Swinburne has undertaken the office of editor. He is assisted by a strong body of abstractors, many of whom are recognised authorities on their own subjects, and authors of well-known books on physics. In the January number there are abstracts of 114 papers, of which 25 are on General Physics, 22 on Light, 12 on Heat, 1 on Sound, 34 on Electricity and Magnetism, and 19 on Chemical Physics. The price to non-members of the Society is two shillings and sixpence; but as the cost for a year at this rate exceeds the subscription to the Society, it is probable that the number of members will increase for this, if for no other reason. It is hoped that this will be so. Many branches of physics, unlike chemistry and electricity, have no great industry behind them. It is therefore necessary that all who care for the study of pure physics should rally to the support of the Physical Society in its new undertaking. The meetings of the Society are now held in Burlington House, in rooms hospitably put at its disposal by the Chemical Society. They are held at five o'clock on Fridays, so that persons who may come to town to attend them, can afterwards go on to the Royal Institution. If an author so desires, the publication of his paper will not be delayed for reading. Copies of the paper are circulated before the meeting, so that the discussion can begin early and with adequate knowledge. As soon as a paper has been read, an abstract and a short account of the discussion is published in NATURE, in the *Electrician*, and other journals. The paper itself is also communicated to the *Philosophical Magazine*, and is published with an abstract of the discussion in the Society's *Proceedings*.

## *THE NATURAL HISTORY OF THE SOLWAY.*

ALMOST all corners of the British Islands have been so thoroughly investigated by naturalists and collectors, that I may be excused for directing attention to one which seems to have been somewhat overlooked—the southern shore of Kirkcudbrightshire and Wigtownshire. I, at least, do not know of any work which has been done there of late years. The Solway itself, so far as I know, has received no attention at all—its shallow, sandy character not offering much attraction to the student of marine zoology.

Yet the surrounding district is, in other respects than its natural history, an extremely interesting one—very varied and beautiful in its scenery, secluded and quiet, and out of the usual track of tourists; with many picturesque and ruinous relics of a bygone age, abounding in streams and lochs suited both to naturalist and angler, and associated ineffaceably with two, at least, of Sir Walter Scott's finest works, "Guy Mannering" and "Redgauntlet," to say nothing of the "Raiders" of a more recent author, Mr. Crockett. It is, moreover, easily accessible, and I suppose it is probably due to the lack of hotels and other tourist accommodation that it is so little known except to residents in the immediate neighbourhood.

The bit of the district best known to me extends from the estuary of the Nith—separating Dumfriesshire from Kirkcudbrightshire—on the east, to the Water of Fleet, which empties itself into Wigtown Bay, on the west. This coast-line is of very diversified character, flat and sandy eastward, where it has behind it a large tract of marsh-land, the haunt of innumerable wild fowl, but rising eastward into precipitous cliffs of sandstone and limestone, which form in some places isolated pillars of considerable height, and in others are hollowed out into caverns, some of which are locally associated with the name of Scott's piratical hero, Dirk Hatteraick. Some of the streams—notably the Water of Urr—come down through a background of granitic hills, bringing with them a vast amount of fine detritus which is deposited on the sides of their estuaries and in the Solway itself, round about their mouths. In such cases the natural result is a very flat shore, composed of soft muddy sand, stretching out very far seaward, and at low water uncovered for stretches of many miles—a state of things not unlike that which is found in the more familiar Morecambe Bay at Grange-over-Sands. These muddy expanses, when left by the tide, are seen to be covered with the contorted mounds thrown up by innumerable lug-worms, and so closely packed are these that there is rarely a space of more than a few inches untenanted by its worm. They form, in fact, quite a conspicuous feature in photographs taken under these conditions, and I do not doubt that the worms themselves, passing through their bodies so much mud laden with decomposing organic matter, which they thus absorb and assimilate, contribute materially to the sanitary purification of what would otherwise become a reeking, pestiferous swamp. Beyond these lug-worms, I am unable to say anything about the larger mud-inhabiting fauna of the district. I thought it very likely that *Echinocardium cordatum* and, perhaps, *Synapta* might be found, as they are in some similar localities in the Firth of Clyde, but the little time which I spent in digging for them did not suffice to disclose any specimens; nor have I had any opportunity of dredging in the Solway Firth. The water is shallow, and the bottom uniformly sandy. I think it would be sure to yield interesting microzoa belonging to such groups as Copepoda and Ostracoda; perhaps also Cumacea and Mysidæ, but the absence of cast-up débris on the shore, either of the larger Crustacea or Mollusca, seems to indicate a dearth of those creatures outside. The littoral zone being chiefly of the flat sandy or muddy character already described, there is not, except in certain restricted areas, much opportunity for shore-hunting of the ordinary kind. But, away from the "sphere of influence" of the estuarine mud, there occur occasional patches of inter-tidal rock with promising-looking pools; these are, however, fearfully storm-swept, and incapable of affording sufficiently secure attachment for many adherent animals. A few common Hydrozoa, such as *Sestulariæ* and *Campanulariæ*, a few patches of "*Hydratuba*" and Ascidians were, I think, with *Alcyonidium gelatinosum*, about all that I noticed. Among swimming things were, however, many Amphipoda and Copepoda, and I took also several specimens of *Mysis Lamornæ*. But my most interesting captures were made by washing the muddy deposit found on the bottoms of some rock-pools, and by netting amongst the weeds of pools situated above ordinary high-water-mark, though still subject to occasional tidal influx. The Copepoda found in such pools will be described elsewhere, but it may be noted here that in some of the inland peaty pools and ditches of the neighbourhood occurred an interesting Ostracod, *Cyclocypris globosa*; and in the White Loch, a species still more interesting and more capricious in its distribution, *Darwinula Stevensoni*.

As regards the botany of the district, I can say very little. My last two visits were made about midsummer, and at that time the sea banks were gorgeous with masses of thrift and red cranesbill (*Geranium sanguineum*), the marshy flats with golden fields of water-flag, the fells with thickets of *Rosa spinosissima* and numerous orchids, the most conspicuous of which was the sweet-scented species, *Gymnadenia conopsea*. These, of course, are all flowers which cannot be overlooked, and are an ever-present delight to the eye and mind: less alluring species, which need to be hunted for, were for the most part passed unnoticed, and such as I did gather were of no particular interest.

G. STEWARDSON BRADY.

## PROFESSOR ARTHUR CAYLEY, F.R.S.

MATHEMATICAL science has suffered a grievous loss by the death of Prof. Cayley, which occurred on Saturday last, at Cambridge. There is hardly a branch of pure mathematics which is not indebted to him for original contributions of the highest value, while the important problems which have been elucidated by him are so numerous, and cover so wide a field, that he was certainly one of the greatest mathematicans which the world has ever known.

It was in September 1883, when Cayley was President of the British Association, that he was ranked among our "Scientific Worthies," Dr. G. Salmon being his biographer. We refrain, therefore, from giving a long notice of his life, and content ourselves with a brief sketch of his scientific work.

Cayley was born August 16, 1821, at Richmond, Surrey. At a very early age he showed great liking and aptitude for arithmetical calculations. He entered King's College School, London, at the age of fourteen, and three years later went to Cambridge, where he entered Trinity College. In 1842 he came out as Senior Wrangler and First Smith's Prizeman. Sir George Stokes had been Senior Wrangler in the previous year, and the late Prof. Adams obtained the distinction in 1843.

While still an undergraduate, Cayley commenced his career of mathematical publication by a paper in the *Cambridge Mathematical Journal* for 1841, but it was not until 1852 that he addressed a memoir to the Royal Society, of which he was elected a Fellow in the same year. Very soon after taking his degree at Cambridge, he entered the legal profession, and was called to the Bar in 1849. But during his career as a barrister, he was constant to his first love, mathematics, and it was while in legal practice that some of his most brilliant mathematical discoveries were made. In 1863, after fourteen years of chamber life in Lincoln's Inn, he returned to Cambridge to fill the newly-instituted Sadlerian Professorship of Mathematics, and no one could have been better fitted than he to discharge the duties of the holder of the chair, viz. "to explain and teach the principles of pure mathematics, and to apply himself to the advancement of the science."

With regard to Cayley as an original investigator, his special merit has been described by Mr. Glaisher who termed him "the greatest living master of algebra." It is difficult to select the work for which he will be the best remembered, but Prof. Salmon defined it as "his creation of an entirely new branch of mathematics by his discovery of the theory of invariants, which has given quite a new aspect to several departments of mathematics . . . And the effect has been that the knowledge which mathematicians now possess of the structure of algebraic forms is as different from what it was before Cayley's time as the knowledge of the human body possessed by one who has dissected it and knows its internal structure is different from that of one who has only seen it from the outside."

Among the honours which Cayley received, may be mentioned the Royal Medal of the Royal Society, awarded to him in 1859, and the Copley Medal in 1882. He was a correspondent in the section of Astronomy of the Paris Academy of Sciences, and was a Fellow or Foreign Member of many other societies and academies, both at home and abroad. He was given the honorary degrees of D.C.L. by the University of Oxford in 1864, and the LL.D. by Dublin University in the following year. Later, the University of Edinburgh conferred upon him a similar honour, and he received the degree of Sc.D. from his own University. The Universities of Leyden, Göttingen, and Bologna also conferred upon him the degree of Ph.D. In 1890, the President of the French Republic made him an officer of the Legion of Honour. This distinction was granted in consequence of a request addressed to the French Minister of Foreign Affairs by the President and other members of the Academy of Sciences.

Cayley's mathematical papers, commencing in the year 1841, have appeared in every periodical mathematical publication of importance in Europe and America. In the year 1887 he undertook the work of editing the series of ten quarto volumes, in which the Syndics of the Cambridge University Press are publishing his collected mathematical papers. The publication of these volumes commenced in 1889, and six of the volumes were reviewed in these columns a year ago (NATURE, January 18, 1894). The number of papers which appear in the six volumes is 416. Altogether seven volumes have as yet appeared. As Cayley is responsible for 724 titles in the Royal Society Catalogue down to 1883, and he has since produced a considerable amount of mathematical work, it seems improbable that ten volumes will be sufficient to contain the results of his prodigious activity and enormous literary industry.

What more need be said about this great master of mathematics? He sacrificed prospects of advancement in the law in order to follow the mathematical work to which he was devoted. He had the power to teach, and the ability to extend the boundaries of knowledge. He was "as distinguished for the amount and universality of his reading as for his power of original work." Truly, his memory will "outlive the life of dust and breath."

The funeral service will take place in the Chapel of Trinity College to-morrow (Friday). Lord Kelvin will be present to represent the Royal Society, and other men of science will probably attend to do honour to the memory of their brilliant fellow-worker.

## NOTES.

WE are enabled to state that the communication to the Royal Society on "Argon, a new Constituent of Air," by Lord Rayleigh and Prof. Ramsay, to be given at the Royal Society to-day, will refer to the density of nitrogen from various sources; to methods for removing free nitrogen from air; to the separation of argon from air by diffusion; to the density of argon; to its spectrum (on which a short paper will be read by Mr. Crookes); and to its behaviour at low temperatures. It is interesting to note that Prof. Olszewski, of Cracow, has liquefied and solidified the gas, and will communicate a short paper on the subject. The solubility in water is also recorded. Various attempts to induce chemical combination are described, and general conclusions are drawn in a final section. The ratio of its specific heats shows it to be a monatomic gas, and proves that its atomic weight is approximately 40. The meeting will not be held in the apartments of the Royal Society, but in the theatre of the University of London.

THE metric system of weights and measures is to be introduced into Tunis on March 1.

DR. BREDICHIN has resigned the Directorship of the Pulkova Observatory, on account of ill-health.

DR. E. KÜLZ, Professor of Physiology in the University of Marburg, has just died. He carried out a number of important researches in physiological and pathological chemistry.

SIR JAMES COCKLE, who held the post of Chief Justice of Queensland from 1862 to 1879, died on Monday, at the age of seventy-six. He was elected a Fellow of the Royal Society in June 1865.

PROF. LEWIS R. GIBBES, of the College of Charleston, South Carolina, U.S.A., whose death occurred towards the end of last year, was born August 14, 1810. He was a Professor in the above-mentioned College for more than fifty years, from 1838 to 1892; at first as Professor of Mathematics, afterwards of Astronomy, Chemistry and Physics. Prof. Gibbes published a number of articles on astronomy, natural history, &c., in various journals and in the publications of scientific societies.

IT will be remembered by our electrical readers, that at the contest organised by the City of Paris in 1889 for the best electric meter, Prof. Elihu Thomson was awarded the prize of five thousand francs. Desiring that this sum should serve for the development of the theoretical knowledge of electricity, Prof. Thomson arranged to offer a prize for the best work on one of four important questions in electricity. The papers had to be sent in by the middle of September 1893, but the decision of the Committee organised to adjudicate upon them has only lately been made known. Four memoirs were received, one written in German, one in French, and two in English. It was decided that each of the two memoirs in English deserved the prize. One was by Dr. A. Webster, of the Clark University, Worcester, U.S.A., the subject being "An experimental determination of the period of electric oscillations." The subject of the other memoir was "An examination of the absolute accuracy of the formula for calculating the period of free oscillation of a discharge condenser under circumstances such that the resistance of the circuit has no appreciable disturbing effect." This memoir dealt practically with a determination of "$v$" by a method of free oscillations, and the authors were Prof. O. Lodge and Mr. R. T. Glazebrook. Ultimately it was decided to award a prize of five thousand francs for each of these papers, the money for the purpose having been collected. The collection of the additional money caused the delay in the publication of the decision of the Committee.

THE opinion has often been expressed that corn or at least grass could be profitably cultivated on the high plateaux of Norway. Dr. Hans Reusch, the Director of the Norwegian Geological Survey, concludes, however, in a recent publication, that the soil which once existed, was nearly all scraped away during the Ice Age, and that cultivation could not now be carried on with much success.

THE Royal Photographic Society, which became incorporated on January 1 in this year, have determined that the Society shall hereafter consist of two classes, Members and Fellows. In future, no members will be admitted to the fellowship until they have given the Council satisfactory proof of the possession by them of suitable qualifications for the title F.R.P.S., which in this way will become a guarantee of ability on the part of its holder in either scientific or artistic photography.

DURING the past week, snow has fallen over all parts of the British Islands; in Scotland and the north of Ireland the amounts have been large, and even in the Channel Islands a depth of six inches was recorded. Very sharp frosts have also been experienced in all parts, and for some days the thermometer in places has not risen above the freezing point. The following low readings have been notified to the Meteorological Office: 8° at Llandovery, on the 25th; 2° at Hillington (Norfolk), and 11° at Yarmouth, on the 27th; and 9° at Loughborough, on the 29th January. At Haparanda, in the Gulf of Bothnia, a temperature of − 24° was recorded on January 26 and 29, and over Europe generally the weather was very cold, frost and snow occuring as far south as Nice and Biarritz. A dense fog occurred in London on the afternoon of January 29.

THE twenty-fifth anniversary of the transfer of the telegraph to the State in the United Kingdom was celebrated on Monday, by a banquet at the Hôtel Métropole, under the presidency of the Postmaster-General, Mr. Arnold Morley. The very remarkable developments of telegraphy during the last quarter of a century is shown by some statistical information furnished to the guests. The telegrams have risen from 6,830,000 to 71,465,000, the mileage of line from 14,776 to 32,881, the mileage of wire from 59,430 to 205,304, the instruments in use from 670 to 8500, the number of words per minute capable of being transmitted on the fastest form of instrument from 70 to 600, and the offices from 2932 to 9637.

ON Wednesday, February 6, the Hon. T. F. Bayard, United States Ambassador, will distribute the prizes to evening students of the People's Palace, Mile End Road, E.

THE following are the names of the candidates who passed the recent examination of the Institute of Chemistry:—A. E. Bell, C. S. Ellis, Dr. M. O. Forster, J. Lones, G. H. Russell, W. H. Sodeau, W. L. Sutton, and W. G Young.

ON Thursday afternoon, February 14, Mr. L. Fletcher, F.R.S., Keeper of Minerals at the British Museum, will begin a course of three lectures at the Royal Institution on Meteorites. The Friday evening discourse on February 8 will be delivered by Dr. G. Sims Woodhead, his subject being "The Anti-toxin Serum Treatment of Diphtheria."

IN accordance with the scheme recommended by the Royal Commission, telegraphic and telephonic communication has been established by the Post Office authorities in connection with the Liverpool life-boat service and look-out stations, and also at various points on the Welsh coast.

ACCORDING to the Paris correspondent of the *Lancet*, a survey of the statistics hitherto published in divers countries of the results of the application of Behring and Roux's method in the treatment of diphtheria up to the last day of December 1894, gives a total of 2700 cases with 433 deaths, or a mortality of 16 per cent.

A GENERAL meeting of the members of the Federated Institution of Mining Engineers will be held on Tuesday, February 12, at 10.30 a.m., in the Examination Hall of the Mason Science College, Birmingham. Arrangements have been made for visits to collieries, &c., on the following day.

THE third series of lectures arranged by the Sunday Lecture Society begins next Sunday afternoon, in St. George's Hall, Langham Place, at 4 p.m., when Mr. A. Smith Woodward will lecture on "The Restoration of Extinct Animals." Lectures will subsequently be given by Dr. R. D. Roberts, Prof. Henry E. Armstrong, F.R.S., Mr. C. T. Whitmell, Dr. C. W. Kimmins, Mr. Douglas Carnegie, and Mr. W. Mayhowe Heller.

THE twenty-second annual dinner of the old students of the Royal School of Mines took place on Friday evening, at the Criterion Restaurant, under the presidency of Mr. W. H. Greenwood. A large number of guests were present, among them being General F. T. Lloyd, Mr. Jeremiah Head, Prof. J. W. Judd, Prof. Roberts-Austen, Mr. H. A. Wiggin, Mr. E. Matthey, Prof. W. A. Tilden, Prof. A. W. Rücker, Prof. G. B. Howes, Mr. W. Gowland, Dr. W. P. Wynne, Prof. C. V. Boys, Prof. J. B. Farmer, and Prof. A. R. Huntingdon.

THE following arrangements have been made for lectures at the Royal Victoria Hall, Waterloo Bridge Road, S.E., during February: Sir Colin Scott Moncrieff on "Egypt and the Nile"; Mr. Smith Woodward on "A Visit to Russia"; Dr. J. Norman Collie on "The Alps around Mont Blanc"; Prof. Ramsay, F.R.S., on "Some New Discoveries about the Air." This lecture will have special reference to the investigations by Lord Rayleigh and Prof. Ramsay, which resulted in the discovery of a new constituent of the atmosphere.

THE twenty-first general meeting of the Association for the Improvement of Geometrical Teaching was held at University College on January 19, Dr. R. Wormell, the President, in the chair. The report of the Council, proposing the continuation of the *Mathematical Gazette*, and the Treasurer's report were read and adopted. Dr. Larmor, of St. John's College, Cambridge, was elected President in the place of Dr. Wormell, who retires; the other members of the Council, including the hon. secs., R. Holmes (The Avenue, St. Margaret's, Twickenham) and C. Pendlebury (53 Gunterstone Road, West Kensington), were re-elected. After the elections, Mr. E. M. Langley gave some geometrical notes, and Mr. G. E. Heppel read a paper on "Algebra in Schools." After an adjournment, Dr. Larmor took the chair, and papers were read by Rev. C. Taylor ("The A. I. G. T. Syllabus of Geometrical Conics") and Rev. J. J. Milne ("The Conics of Apollonius"), and Prof. Lodge gave some notes on Mensuration. Interesting discussions followed these. All communications with respect to the *Mathematical Gazette* should be addressed to the Editor, 16, Adelaide Square, Bedford.

COLONEL A. T. FRASER, writing to us from Bagdad, says that while travelling lately on the right bank of the Euphrates, he noticed a pair of caves near the usual black woollen cloth tent lived in by the Arabs, and found that, as evening drew in, a number of cows were driven down, and the caves shut with plugs of straw and thorns. "It was evident," he says, "that this must have been the primary use to which those early types of man of the flint and bronze ages, about whom we know so little, put the so-called cave dwellings, that of sepulture being an after-thought. One would imagine, reasoning hastily, that cows and Arabs should have more properly changed places. But the Arabs bring the experience of thousands of years to bear on this question, and prefer the free air to a confined atmosphere suitable only to ruminant beasts, and tents to caves. Having alluvial soil to deal with, the Arabs in this instance dug pits about four feet deep, and domed over the top with brushwood and straw to complete the caves, the whole showing but little above the surface. There was no need of permanence, as encampments shift with the seasons. Under other circumstances the old "cave" races would have dug the entire cavity out of the solid, but still put in their cattle, and remain outside themselves."

FOR some classes of observations involving the use of a spectroscope, the movement of either collimator or observing telescope is objectionable, and for such work it becomes necessary to rotate the prism in order to bring different parts of the spectrum into the field of view. If the condition of minimum deviation be of no importance, as in the case of Mr. Tutton's apparatus for obtaining monochromatic illumination, there is no objection to turning the prism in this way, but if the condition of minimum deviation for the central ray in the field is to be retained, some special device is essential. This has already been accomplished in various more or less elaborate ways, but Mr. F. L. O. Wadsworth has now indicated a means of satisfying this condition very simply (*Astronomy and Astrophysics*, December 1894). The general solution of the problem is effected by the introduction of a mirror into some part of the spectroscopic train between the slit and the focal plane of the observing lens, the mirror having an angular movement equal to one half the change in angular motion of the ray refracted at minimum deviation. The mirror may be disposed in several ways, but that finally adopted for use with the spectro-bolometer is to place it in continuation of the back face of the prism. With this arrangement the emergent ray is parallel to the incident one, so that a direct vision spectroscope is obtained by the use of a single prism. The prism and mirror are together mounted on the graduated circle of the spectrometer, and by making the axis of rotation of the system coincident with the intersection of the plane bisecting the refracting angle of the prism and the plane of the mirror, there is no lateral displacement of the ray at minimum deviation. The idea seems to be an excellent one, and capable of wide application.

THAT gales have a considerable effect upon the heights of tides is very well known. The gale of January 23, furnished an example of this at the East India Dock. According to a letter in the *Times*, high water was due at the Dock at 12·46 a.m. on January 24. At ten o'clock on the previous evening, however, the tide had risen three inches above Trinity datum, and then fell 5 feet 4 inches to midnight. It again rose five inches to 1 a.m., when it went away altogether. The phenomena suggest that, probably, the records of self-registering tide gauges, when discussed in connection with high winds and cyclones, will furnish useful results. Prof. Cleveland Abbe notes in the *Monthly Weather Review* that, during a hurricane at Charleston last September, the excess of the actual over the normal high water mark increased gradually until it reached more than five feet. In this connection some observations on the indication of distant storms by tides are of interest. Captain E. Jones, who for many years kept logs of deep-water voyages of Lieutenant Maury, states that, previous to a cyclonic storm which occurred early in September, he noticed that at low water the tide did not fall near as low as under ordinary conditions, and he came to the conclusion that a cyclone was approaching, as he had noticed before that under these conditions such storms are very certain to make their appearance. He testifies "that this abnormal condition is an infallible indication of a storm approaching or passing by. A storm directly in from seaward generally affects the flood tide even more than a low water tide, but in the present case the high water was about normal. A long experience gives me great confidence in the barometer as affording valuable prognostication of a storm, but this tidal wave along the coast preceding a cyclone must, as it seems to me, give absolute proof that some kind of storm is in progress; the astonishing thing is that the ocean level is affected by the cyclone at such a great distance, and especially ahead of it."

IN the *American Engineer* for January, Prof. H. A. Hazen gives some of the results of a very interesting balloon ascent made in the "Svea" at Stockholm, by S. A. Andrée. The account is taken from the *Proceedings* of the Swedish Academy, vol. 20, part ii., No. 3. The balloon travelled for 136 miles east over the Baltic, the highest point reached being 9900 feet, and at the time of the ascent, Stockholm was nearly in the centre of a high barometric area; this fact, in connection with the position of the balloon over a wide expanse of water, adds great interest to the observations. The diminution of temperature with height, allowing for increasing heat during the day, was about 1° in 250 feet, in the first 4000 feet, which is noteworthy, as the sea surface causes less diminution with height. Above 4000 feet, clouds were encountered, and these changed the rate of diminution, while at the highest point, the result was 1° in 400 feet. The most interesting feature is the great dryness of the air above 7500 feet; at 6000 feet the relative humidity was 100 per cent., and at 1800 feet higher it was only 4 per cent. Prof. Hazen states that this is the most extraordinary fall in humidity ever observed, and it shows how little we really know of atmospheric conditions, even at very low heights. The value of the results to be obtained by balloon ascents in determining the laws of storms is beyond doubt, and Prof. Hazen strongly advocates that such researches should be undertaken.

THE origin of the Alpine Serpentines has always been a subject for wide differences of opinion. The Italian school of geologists until lately upheld the view that they were metamorphosed sedimentary rocks, while English and German geologists maintain their intrusive nature. One of the latest contributions to this subject comes from Dr. Ernst Weinschenk who, in the *Abhandlungen* of the Bavarian Academy of Sciences (Munich, 1894) describes the occurrence and petrography of the serpentines of the Great Venediger, a mountain in the Eastern Alps of North Tyrol. He finds that they are undoubtedly intrusive rocks, formed by the consolidation of a peridotite magma that was squeezed in between the foliation-planes of the neighbouring mica-schists during the great Alpine earth-movements. They thus occur as a series of laccolites (*linsen*), which, we may observe, resemble in their origin those of Shropshire rather than the typical laccolites of the Henry Mountains, which were intruded into horizontal strata. After their first consolidation, the peridotites were crushed by the continuation of the earth-movements, and by the continued action of superheated vapours and solutions were gradually converted into their present condition. The evidence of these changes is seen in the minute structure of the rocks, which, as well as the nature of the metamorphism they have produced in the surrounding schists, is exhaustively described in the paper, and illustrated by a number of micro-photographs.

A SECOND paper, by the same author, deals with the gneiss and granite of the same part of the Alps. These have also been studied by Prof. Löwl, whose results are published in the *Verlag der k.k. geol. Reichsanstalt* (Vienna, 1894). This author treats the subject from a structural point of view, and his memoir is illustrated by a map and several sections; while Dr. Weinschenk describes the petrography in detail. Both authors assert the undoubtedly intrusive origin of these rocks, and incline to class them with the pre-carboniferous "Protogine" of the Western Alps. Dr. Weinschenk regards certain peculiarities in the granite as due to lateral pressure during the period of consolidation, and proposes the term *Piezocrystallization* for the development of structures under such conditions.

THE elasticity of solid gelatine solutions is the subject of an investigation by Erwin Fraas, in *Wiedemann's Annalen*. Sticks of aqueous gelatine were obtained in the following manner. Brass tubes, about a foot long and half an inch thick, were cut in two at the centre and joined by wire rings. They were closed at one end with a cork, and were placed vertically. The gelatine solutions were then poured in, care being taken to prevent adhesion by rubbing with olive oil. The suspension of the sticks was a matter of some difficulty, but it was accomplished by brass clamps of the shape of a cylinder, cut along its length on both sides and roughened inside, which were gently pressed on the gelatine by a spring. It was found that in no case did the volume change by stretching, the diminution girth being compensated by the increase of length. The addition of common salt impaired the elasticity and strength of the sticks very considerably, making them unfit to support a pound weight, while part of the water could be replaced by glycerine, cane sugar, or gum arabic, without making any difference.

THE *Comptes-rendus* of the Paris Academy, of January 14, give an account of some modifications of an electrical anemometer formerly used by the Rev. Marc Dechevrens, at Zi-ka-wei, for recording the horizontal and vertical movements of the atmosphere. The instrument, which is being constructed by M. Richard, is to be erected at the observatory of the Jesuit College in Jersey, and possesses some novel contrivances intended to ensure its satisfactory performance. The fan of the anemometer, which gives the horizontal component, is formed by portions of a cylinder; this arrangement was devised by M. Dechevrens, and is said to give excellent results. There is also an arrangement which assures sufficient duration to the electric contacts, to excite the electromagnets, while preventing prolonged contacts, which exhaust the batteries without doing any good. Two wires out of seven which exist in similar instruments are dispensed with; this is also an important simplification if the registrations are to be recorded at a distance.

THE current number of *Wiedemann's Annalen* contains a paper by Max Weber, on electromagnet pull. The author has measured the pull exerted on a long iron wire, one end of which projects within a helix, when a known current flows through this helix, producing a magnetic field of known intensity. The wire under examination is suspended horizontally by four silk fibres in the same way as in a ballistic pendulum. The displacement of the wire under the action of the coil is measured by means of a microscope, and from a knowledge of the weight of the wire and the length of the suspending fibres the pull can be calculated. The author has investigated the connection between the pull per unit cross-section of the wire ($p_{\parallel}$), the strength of the field within the helix (H), and the intensity of magnetisation (J), and finds that $p_{\parallel} = \text{JH}$, when the length of the wire is parallel to the lines of force of the helix, and the diameter of the wire is very small compared with its length. The author has also examined the pull perpendicular to the lines of force, by using two coaxial magnetising coils separated by a small interval, the wire being placed with its length perpendicular to the axes of these coils, and its end passing through the space left between them. If the pull per unit area of cross-section of the wire under these conditions is called $p\perp$, then $p\perp$ is always, in the case of iron, less than $p_{\parallel}$. For fields having an intensity of about 100, the ratio $p_{\parallel}/p\perp$ is about 100, but decreases rapidly with increasing field strengths, and appears to approach unity as a limit. Thus for $\text{H} = 12{,}000\ p_{\parallel}/p\perp = 1 \cdot 11$.

IT is known that the direction of the pendulum line shows a considerable anomaly around Moscow. The line is deviated at Moscow by 10″·6 to the north; at Tsaritsino, in the south-east, the deviation is only 0″·5 in the same direction; and at Podolsk, which is twenty-one miles from the capital, the deviation takes the opposite direction, to the south, and attains − 2″·7. It has been supposed that beneath the neutral zone, at Tsaritsino, there must be great cavities in the rocks, or that the rocks, as a whole, have a density below the average. We now learn from a note by General Stebnitskiy, in the last issue of the *Izvestia* of the Russian Geographical Society (1894, No. 4), that the pendulum observations which have been made around Moscow by M. Iveronoff, give full support to the above supposition. The differences between the lengths of the second-beating pendulum, observed and calculated, being positive at Moscow and at Podolsk (+ 0·0108 and + 0·0064 millimetres respectively), the same difference is negative above the neutral zone of Tsaritsino (− 0·0228 millimetres), thus showing a deficiency in the acceleration due to gravitation to the amount of 1/30,000th of the total force.

THE last number of the *Izvestia* of the Russian Geographical Society contains a very interesting account of Baron Toll's expedition to Arctic Siberia and the New Siberia Islands. Baron Toll was sent out by the Academy of Sciences to examine the body of a mammoth which was said to have been discovered on the banks of the Balakhna, a tributary of the Khatanga Bay, and altogether to continue the work which had been entrusted to Chersky, but was interrupted by his death. Lieut. Shileiko undertook the surveys, as well as the astronomical and magnetical observations. After a three months' journey the two explorers reached the village Kazachiye, at the mouth of the Yana, in 71° north latitude. A visit to the mammoth soon proved that there was nothing left but a few pieces of skin with its hair clothing, parts of the extremities, and a broken skull of a young mammoth. A number of remarkable explorations and surveys, astronomical and magnetical observations, and geological explorations were, however, carried out. The chief geological result is the settling of the real positions of the layers which contain relics of the mammoth. They are undoubtedly Post-Glacial, as they overlie the masses of underground ice which form the chief rock of the great Lyakhoff Island, and which, as Baron Toll's observations now prove, are remains of the great ice-sheet which formerly covered both the islands and the mainland, and whose moraines have now been discovered on the mainland. Moreover, these ice masses have the typical granulated structure of the glacier ice, which proves that they have originated from the snow-cover, and could not have originated from any sort of running water. As to the Post-Glacial layers which overlie the above, they contain, besides shells of *Cyclas* and *Valvata* and well-preserved insects, full trees of *Alnus fruticosa*, willows, and birch, fifteen feet high, and bearing perfectly well-preserved leaves and cones. The northern limit of tree vegetation thus spread during the Mammoth period full three degrees of latitude higher than it spreads now, *i.e.* up to the 74th degree, and the mammoths and rhinoceroses of the time lived upon the patches of meadow clothed with the above bushes. It is worthy of note, that the masses of underground ice are not found in the lower parts of the Arctic coast which are known to have been covered by the Post-Pliocene sea, and that they only occur where the land rises a few hundred feet above the present level of the sea—that is, above the evel of the Post-Pliocene ocean.

AFTER considerable delay, Murray's "Handbook for Hertfordshire, Bedfordshire, and Huntingdonshire" has been published. Brief notes on the geology, botany, and antiquities of these counties are given in an introduction.

THE Matriculation Directory (No. xvii.) of the University Correspondence College has just been received. It contains the examination papers (together with solutions) set at the recent matriculation examination, and also articles on the special subjects for next June, and for January 1896.

THE additions to the Zoological Society's Gardens during the past week include a Macaque Monkey (*Macacus cynomolgus*, ♀) from India, presented by Miss Teresa M. L. Monteath; two Little Auks (*Mergulus alle*) from Norfolk, presented respectively by Mr. Hamon Le Strange and Colonel Feilden; a Cardinal Grosbeak (*Cardinalis virginianus*) from North America, presented by Mr. F. Beresford Wright; two Leopard Tortoises (*Testudo pardalis*), a Cape Bucephalus (*Bucephalus capensis*) from South Africa, presented by Mr. J. E. Matcham; two Mantells Apteryx (*Apteryx mantelli*) from New Zealand, a Black Iguana (*Metopoceros cornutus*) from San Domingo, deposited; a Hog Deer (*Cervus porcinus*), born in the Gardens.

## OUR ASTRONOMICAL COLUMN.

THE NATAL OBSERVATORY.—Mr. Nevill's report upon the work of the Natal Observatory, during the fiscal year ending last June, has been issued. The staff of the Observatory consists of an astronomical assistant, a meteorological assistant, and a computor, all of them ladies. In spite of such limited assistance, much important work has been accomplished. The observations of Mars during the opposition of 1892 have been completely reduced; and as soon as the corresponding observations made at the northern observatories have been reduced and published, it is proposed to compare the two series, and obtain from them a new determination of the distance of the sun. A contribution to the knowledge of the variation of latitude is included in the report. Since 1884 a number of observations have been made, by Talcott's method, to determine the latitude of the observatory. The observations invite consideration, on account of the fact that they were made and reduced before any special attention had been directed to the variation, arising from the suspected periodical inequality, in the direction of the polar axis of the earth. The mean latitude, deduced from the 1023 observations made during the six years 1884–1890, was 29° 51′ 46″·68. The results obtained, from the separate observations of each year, show a steady gradual decrease since 1885. The observed latitude of the Observatory seems to have reached a maximum in that year, and to have steadily decreased since, at a nearly uniform rate of 0″·27 per annum. The rate of decrease up to 1890, however, appears to have quickly diminished, indicating a periodical irregularity in the apparent value of the latitude of the Observatory. Mr. Nevill remarks that a great deal of important work has accumulated at the Observatory, but the Government of Natal will not afford the necessary facilities for printing and publishing it.

THE NEW DUDLEY OBSERVATORY.—The disadvantages of the old situation of the Dudley Observatory had long been recognised, but it was not until 1892 that the generosity of Miss Bruce and other "friends and neighbours of the observatory," permitted the removal of the observatory to its present more favourable site. From an account given by the Director, Mr. Lewis Boss, in the *Astronomical Journal* No. 334, we learn that the observatory grounds consist of six acres, situated in an area of about forty acres, designed to form part of the park system of the City of Albany. The buildings appear to be all that can be desired, and many advantages will no doubt be derived from the provision of dwelling accommodation for the observers. The Transit Circle provided in 1857 has been re-erected with some slight additions, and it is satisfactory to learn that its large aperture of 0·203 m. and focal length of 3 metres, is no detriment to its excellence. A new equatorial, denominated the Pruyn, having an aperture of 31 centimetres, has been presented by the sons of a former President of the Board of Trustees. In this instrument, a photographic combination is obtained by replacing the flint glass of the visual telescope with a second one, and it is believed that this arrangement will be a complete success.

No elaborate programme of work is promised, but "the logic of events and inclination invites the observatory to undertake the comprehensive observation and discussion of stars known to have sensible proper motions." The Transit Circle will accordingly be devoted to this work, and the equatorial will take a subordinate place, "though it is expected that the zealous young assistants will continue to give a good account of themselves in work with this instrument, so far as circumstances permit."

THE MILKY WAY.—Returning to the subject of the distribution of stars in the celestial sphere, C. Easton (*Ast. Nach.* 3270) has derived some results of considerable interest by limiting his attention to two comparatively small regions of the Milky Way, one in Aquila, and another in Cygnus, the latter embracing a specially dark as well as a notably bright region. For each of these regions he finds that the general luminosity of the Milky Way corresponds very much more closely with Argelander's stars of magnitudes 9·1–9·5, than with the stars of greater brightness. A diagram in which all the stars of the Bonn maps have been reduced to the corresponding number of stars of mag. 9·5, shows very little similarity with the features of the Milky Way. Extending his inquiries to the photographs taken by Dr. Max Wolf, showing stars down to mag. 15, he shows that the very feeble stars followed the same law of distribution as those of mags. 9·1–9·5. This correlation appears to indicate that the faintest stars and those of the 9th or 10th mag. probably form part of one system, and are at nearly the same distance from us. At the same time, some stars brighter than 9th mag. seem to be intimately associated with the Milky Way.

The hypothesis of an annular system, relatively isolated from the central part of the great galactic system, is regarded as not incompatible with the distribution of stars which he has found. For if, at nearly the same distance from us, stars vary so much in size or intrinsic brightness as to give magnitudes ranging from 9 to 15, there seems no reason why some should not be of greater brightness than 9th mag.

There is nothing to prove, however that the various parts of the Milky Way are at an equal distance from us, nor even that it may be an enclosed ring. It does not appear improbable that subsequent researches may show the existence of one or several spirals emanating from a central accumulation, and recurving so as to form a nearly annular system, or one consisting of nearly concentric rings. However it may be, Mr. Easton's results seem to indicate that the portion of the Milky Way accessible to our means of observation, has but little thickness in relation to the diameter.

In a paper on the same subject (*Knowledge*, February), Mr. Maunder finds it difficult to resist the conclusion that the "dark lanes" of the Milky Way are really regions of barrenness, and regards these features as indications of a process of condensation going on in the stellar as well as in the nebulous matter.

THE SYSTEM OF ALGOL.—Quite recently (NATURE, vol. xlv. p. 446) Mr. Chandler credited Algol with an obscure companion in addition to that which was recognised by Goodricke, and the existence of which has been fully confirmed by the investigations of Pickering and Vogel. Mr. Chandler's conclusions were based on a discussion of the systematic irregularities of the epochs of minima, and were apparently confirmed by a later discussion of the proper motion of Algol itself (NATURE, vol. xlix. p. 349). The evidence of irregular proper motion, however, is not regarded as conclusive by some authorities, and M. Tisserand, the Director of the Paris Observatory, is apparently one of the unconvinced. He has therefore attempted to find some other explanation of the phase variations (*Comptes-Rendus*, January 21, 1895), and the result is to show that they can be simply and sufficiently explained by supposing a single dark companion moving in an elliptic, instead of a circular, orbit; and, in addition, that the bright star exhibits a sensible polar compression. The result of this departure from the spherical form would be a movement of the periastron point, and this would explain the apparent irregularities.

Assuming that the plane of the orbit is coincident with the equator of Algol, its eccentricity is found to be 0·132, and the polar diameter is shorter than the equatorial by $\frac{1}{200}$.

The consequences of these conditions would be a very slight variation of minimum brightness in the long period of 140 years, and an entirely negligible difference in the time of passage to minimum and recovery of normal brightness. The total duration of the eclipse, however, will vary very considerably. Taking the mean epochs 1800 and 1884 for the observations of Wurm and Schonfeld respectively, M. Tisserand finds that the duration would be increased in this time by 1·63 hours. Since the times given by these observers are 6·5h. and 9·0h. respectively, M. Tisserand is entitled to regard this as confirmation of his hypothesis. He points out the importance of spectroscopic observations at short intervals from minimum, in connection with his explanation.

The irregularities in U Ophiuchi and U Cephei are probably to be explained in the same way.

## *THE EXPLOSIVE NATURE OF THE SODIUM AND POTASSIUM DERIVATIVES OF NITROMETHANE.*

SOME additional information of an interesting character concerning the extremely explosive sodium and potassium compounds of nitromethane, is contributed to the current *Berichte* of the German Chemical Society by Prof. Zelinsky of Moscow. A short time ago Prof. Victor Meyer described (*Berichte*, 27, 1601) a mode of preparing the sodium compound $CH_2NaNO_2$ in a state of purity. The process consists in diluting a quantity of nitromethane, $CH_3NO_2$, with ether and treating the liquid with a solution of sodium in alcohol, when the sodium compound is precipitated. The precipitate requires to be washed with ether, and is then dried over oil of vitriol; the dry compound thus obtained affords numbers on analysis agreeing with the anhydrous formula above given. In a former method of preparation described by Prof. Meyer, alcoholic soda was employed as precipitant, but the sodium nitromethane obtained invariably contained either water or alcohol; the use of sodium ethylate affords it anhydrous. Even the hydrated compound first isolated proved to be explosive; but upon placing a small quantity of it upon a watch-glass, and warming over a water-bath, in a short time it became suddenly converted into the anhydrous compound which immediately exploded with great violence. When a small quantity of the anhydrous compound prepared by use of sodium ethylate was placed in a test-tube, gently compressed, and then warmed, an explosion of so violent a nature occurred that the test-tube was completely pulverised.

Prof. Zelinsky has recently had occasion to prepare considerable quantities of sodium and potassium nitromethane, and has had the opportunity of testing and observing their explosive power upon a larger scale. He appears to have adopted essentially the same process for the preparation of sodium nitromethane as that described by Prof. Meyer, employing an alcoholic solution of sodium ethylate as precipitating reagent. Being desirous of obtaining the sodium compound perfectly anhydrous, an attempt was made to achieve this object by use of the water bath, but for the sake of precaution only about a gram of the substance was employed as a preliminary test of the efficacy of this method of dehydration. It was fortunate that such was the case, for within five minutes an explosion of so violent a nature occurred, that the watch-glass upon which the compound was supported was reduced to powder, and the water-bath considerably injured. In order to demonstrate the explosive nature of this compound without danger upon the lecture table, Prof. Zelinsky recommends the following experiment:—A thick clock-glass, or better a stout metal plate, is sprinkled with small drops of water, and a very small piece of sodium nitromethane dropped upon it. After a few seconds, provided the amount of water has not been excessive, a deafening detonation occurs, with production of flame and projection of a thick cloud of smoke. The experiment may be varied by placing the substance upon the perfectly dry plate, and invoking its explosion by means of a smart blow with a hard object.

M. Nef has previously (*Ann. der Chemie*, 280, 273) described several of the metallic derivates of the nitroparaffins, and has referred to the instability of the sodium compound, and the possibility of occasional explosions. Prof. Zelinsky now supplements this statement by remarking that an explosion always results from the contact of the dry sodium compound with a minute quantity of water. One of his assistants upon one occasion incautiously placed about five grams of sodium nitromethane in a glass vessel whose surface happened to be moist, with the result that a terrific explosion instantly occurred, which shattered every piece of apparatus upon the table, and the atmospheric wave produced occasioned the sudden extinction of the whole of the gas flames in the laboratory. The assistant fortunately escaped more than trifling injury, but a second such occurrence might have a very different result. This incident will doubtless serve to emphasise the great precaution which is necessary in handling these compounds.

The potassium compound, $CH_2KNO_2$, has been prepared in a similar manner, and found to be even more unstable than the sodium compound, exploding at the ordinary temperature shortly after its isolation. It separates upon the addition of the potassium ethylate in well-defined crystals. The crystalline form, however, soon disappears, and upon rapidly transferring to a filter, an explosion invariably occurs as soon as the compound becomes drained free of most of the mother liquor. The instability of the potassium compound at the ordinary temperature may also be readily demonstrated upon the lecture table. It is, of course, necessary to prepare it freshly on the spot, because of the impossibility of preserving it for any length of time. An ethereal solution of nitromethane is mixed with a solution of potassium ethylate in alcohol, the supernatant liquid rapidly decanted from the precipitate produced, the latter dried as quickly as possible between filter-paper, and left quietly resting upon the paper. After a few minutes the substance explodes with a loud detonation.

These experiments will serve to indicate the extreme instability of the alkali-metal derivatives of nitromethane, and the violence of the explosions produced by their disruption.

A. E. TUTTON.

## RECENT WORK AT HARVARD COLLEGE OBSERVATORY.

THE forty-ninth annual report of the Director of the Harvard College Astronomical Observatory, by Prof. E. C. Pickering, has come to hand. Omitting matters of administration and some of the details, the following summary shows the most important events of the year covered by the report.

### PHOTOMETRIC OBSERVATIONS.

The reduction of the photometric measures of the southern stars observed by Prof. S. I. Bailey in Peru, is now completed, and the catalogue containing the resulting magnitudes is in print. The observations of the first investigation undertaken with this instrument since its return from Peru are nearly completed. About six thousand stars have each been observed on at least three evenings. This catalogue includes all the stars of the Harvard Photometry, eighty lists of comparison stars for variables of long periods, and various stars the magnitudes of which are desired by other astronomers. A study has been made of the atmospheric absorption, especially for very low stars, and its coefficient has been derived on each evening, both for the southern and the northern stars. These values are now applied as corrections to the individual observations, instead of adopting a mean value of the absorption. A new working list has been prepared of the stars north of $-40°$ having magnitudes 7·5 or brighter, and which have not already been observed with the meridian photometer. This list contains about fourteen thousand stars, of which about two thousand have been observed during the last year.

Prof. Pickering refers to Mr. S. C. Chandler's criticisms on the photometric observations made with the meridian photometer. (*Astron. Nach.* vol. cxxxiv. p. 355, and vol. cxxxvi. p. 85.) It is maintained that the meridian photometer possesses the same advantages in measuring the light of a star that the meridian circle does in measuring its position. In both instruments absolute values are determined directly, and they are obtained very rapidly. Stars are identified in the same way in both, rapidly and accurately, and in both the systematic errors are small, even if the accidental errors are in some cases larger than those resulting from other methods. Stars can be observed with the meridian photometer under favourable circumstances nearly at the rate of one a minute, and the average deviation of the results thus obtained does not generally exceed one-tenth of a magnitude.

### ASTRONOMICAL PHOTOGRAPHY.

The number of photographs taken with the 8-inch Draper telescope is 1657. The number taken in Peru with the 8 inch Bache telescope is 1708. All of the spectra photographed with these instruments have been examined by Mrs. Fleming. As a result seven variable stars, U Puppis, V Cancri, V Leonis, T Sagittarii, R Delphini, R Vulpeculæ, and R Phœnicis, have been shown to have the hydrogen lines bright in their photographic spectra. Unsuccessful attempts have been made to photograph the spectra of many other variables of long period when at maximum, and no image has been obtained. This has been found to be due in many cases to large errors in the ephemerides, and has been remedied by depending upon the observations of Mr. W. M. Reed, and making the time of photographing each star depend upon its observed, instead of its predicted, brightness. Eleven new variables have been discovered in the year, from the presence of bright hydrogen lines in their spectra, besides three the variability of which was discovered from changes in their photographic images. The number of stars of the fifth type has been increased by seven, making the total number of these objects 62. Five nebulæ have been discovered from their spectra. The hydrogen line H$\beta$ has been discovered to be bright in the spectra of five stars, and twelve stars have been shown to belong to the fourth type. The spectra of A. G. C. 18049 and 22640 are peculiar. Several photographs have been obtained of the new star in the constellation Norma. At the Lick Observatory it was shown from visual observations that its spectrum, as in the case of the new star in Auriga, had become that of a gaseous nebula. This has been confirmed from photographs taken at Arequipa, which also show that this object is now gradually becoming fainter. The spectra of 4557 stars on thirty plates have been classified for the new Draper Catalogue. On one of these plates covering the region of the variable star $\eta$ Carinæ, 1161 spectra have been measured.

The number of photographs taken with the 11-inch Draper telescope is 912. The lines in the spectrum of $\zeta$ Ursæ Majoris are found to be double in 59 out of 340 images, and of $\beta$ Aurigae in 47 out of 65.

An investigation has been in progress for some time for the detection of stars having large parallaxes or proper motions. Photographs are taken in the usual position with the film towards the object glass, and also with the plate reversed, the photograph being taken through the glass. These are repeated at intervals of six months at the times when the effect of parallax on their right ascension would have its greatest value. Plates thus obtained may then be superposed so that the films shall be in contact, and the two images of each star made to appear like a close double with components north and south. Small changes in position may be detected by changes in the position angle, and the amount of the parallax or proper motion may be measured with great accuracy. Several hundred stars have thus been shown to have no parallax exceeding half a second.

### OBSERVATION IN PERU.

The meteorological station on the summit of Misti, at a height of 19,200 feet, was successfully conducted for several months, one of the assistants, generally Mr. Waterbury, visiting it every ten days, and readjusting the self-recording instruments. Unfortunately, early in September, the shelter containing the instruments was found to have been broken into, and a number of the instruments carried off. Apparently the robbery was committed by two Indians, whose tracks were followed to a considerable distance. The property stolen would, of course, be of no use to the thieves, and its intrinsic value would be a small part of the actual loss. The work at this station was conducted with great labour; a mule path had been built to the summit, and the entire expenditure had been large. It will be a serious loss to science if it proves impossible to maintain the station.

The number of photographs obtained by Prof. Bailey with the 13-inch Boyden telescope is 561, including some remarkable charts. Among them may be mentioned photographs of the Nebula of Orion with an exposure of eight hours, of the cluster $\omega$ Centauri with an exposure of six hours, and of $\eta$ Carinæ with exposures of six and fourteen hours respectively. In some of these, notwithstanding the long exposure, the image shows no deviation from the circular form. This is mainly due to substituting for a finder two eyepieces attached to the main telescope. One of them serves to follow a guiding star in the usual way; the other, directed to another star, shows if the plate needs to be rotated in its own plane. This appears to be an important improvement in making the best photographic charts of long exposure, especially of the polar regions. By the ordinary methods it is impossible to entirely correct such errors as those due to flexure and refraction, which do not depend upon the direction of the axis of the earth.

Attention is again drawn to the importance of making use of the admirable atmospheric conditions at Arequipa. A telescope of the largest size would not only have most favourable opportunities for work, but a field unexplored with such an instrument in the southern sky. Much could be done with a smaller instrument, as is shown by the work already accomplished with the 13-inch Boyden telescope. Out of a list of thirty telescopes having aperture exceeding 14 inches or more, but one is mounted south of latitude + 35°, and this one is not in use. A moderate expense only would be required to carry out this plan.

### WORK WITH THE NEW TELESCOPE.

One of the most important events of the year was a careful trial of the Bruce photographic telescope. Nearly a thousand photographs have been obtained with it. The spectra of the faint stars prove very satisfactory, and stars too faint to be photographed with the other instruments can thus be studied. Bright hydrogen lines have been found in the spectra of S Orionis, S Bootis, W Virginis and S Libræ, and the spectrum of V Ophiuchi has been shown to be of the fourth type. The length of these spectra is about a quarter of an inch, which is sufficient to show much detail in the spectra of fairly bright stars. To study still fainter spectra a prism of crown glass and of smaller angle has been ordered. The absorption of the photographic rays is less for this material, and it is expected that much fainter spectra can be photographed, since the dispersion will also be less. The contract has not yet been filled for the Bruce telescope, since difficulty is still experienced in making charts in which the images shall be circular. Experiments are in progress in this direction, and it is hoped that the method described above as applied to the 13-inch Boyden telescope will prove equally successful with this instrument.

A variety of experiments have been made to determine the photographic magnitudes of the brighter stars on a uniform scale. It is now expected that this can be done with the transit photometer for stars brighter than the third magnitude, and that the scale can be extended to stars from the third to the sixth magnitude by a series of photographs which are being taken with a portrait lens having an aperture of 2·5 inches. The images are thrown out of focus, and the intensity of the circular discs thus obtained can be accurately measured.

## ELECTRIC DISCHARGE THROUGH GASES.[1]

ONE of the most important and interesting branches of physical science is that which deals with the connection between electrical and chemical effects.

The investigations on electrolysis made within these walls by Davy and Faraday proved that the important class of electrical phenomena associated with the passage of electricity through liquids, are connected in the closest way with chemical action. They proved that no electricity will pass through most liquids unless chemical action occurs, and that for each unit of electricity which passes through the liquid there is a definite amount of chemical decomposition.

This case, though it is one where the laws are most accurately known, is but one among many electrical phenomena which are inseparable from chemical action.

So many instances of this kind have been discovered, that we may perhaps venture to hope that we are not far from the time when it will be universally recognised that many of the most fundamental questions in chemistry and electricity are but different aspects of one and the same phenomenon.

Anything which throws light on the connection between electricity and matter, interesting as it is on its own account, acquires additional interest when regarded as elucidating the connection between chemical and electrical effects, and no phenomena seem more suitable for this purpose than those which are the subject of the discourse this evening—the discharge of electricity through gases. For in gases we have matter in the state in which its properties have been most carefully studied, while the investigation of the electrical effects is facilitated by the visibility of the discharge, affording us ocular, and not merely circumstantial, evidence of what is taking place.

The points to which I wish to refer particularly this evening are, firstly, some phenomena connected with the passage of electricity from the gas to the electrode, or from the electrode to the gas; and secondly, some of the properties of the discharge when its course lies entirely in the gas.

By taking a long discharge tube, say, one fifty feet long, and observing the luminous discharge through a rotating mirror, we can trace the course of the luminosity due to a single discharge, say, one due to once breaking the primary circuit of an induction coil; if we do so, we find that the luminosity follows the direction of the positive current through the tube. That is, the luminosity begins at the positive electrode, it then rushes down the tube with enormous velocity, but when it gets to the negative electrode, it receives a check; it does not disappear at once in that electrode like a rabbit going down a hole, but lingers around the electrode some time before entering it. In consequence of this delay in the positive discharge in getting out of the gas, there is an accumulation of positive electricity in the neighbourhood of the negative electrode until the potential fall at this electrode increases to about 200 or 300 volts.

The positive electricity which accompanies the discharge thus finds considerable difficulty in getting from the gas to the metal, though, as I hope to show you later on, as long as it keeps in the gas, it meets with what we may, in consideration of the views sometimes enunciated on this subject, call a ridiculously small amount of resistance, its real difficulty is to get out of the gas.

Though this effect has long been known, it is so important that I will venture to show one or two experiments which illustrate it. The arrangement of the first experiment is shown in Fig. 1. The apparatus consists of a main discharge tube, across which is fastened a diaphragm made of excessively thin platinum leaf; there is a side passage from the tube, leading from one side of the diaphragm to the other, this is connected to a barometer tube, and by raising the cistern containing the mercury I can stop up the passage by a pellet of mercury. We will first observe the discharge when the side passage is open; you see that the discharge, instead of passing across the thin piece of platinum leaf, takes the very much longer route round the side tube, so as to avoid crossing the metal. We will now raise the mercury cistern, and close the side tube by a pellet of mercury; the discharge now has no alternative but to cross the metal at some part of its course, and you see that the main portion of the discharge goes back into the main tube.

Fig. 1.

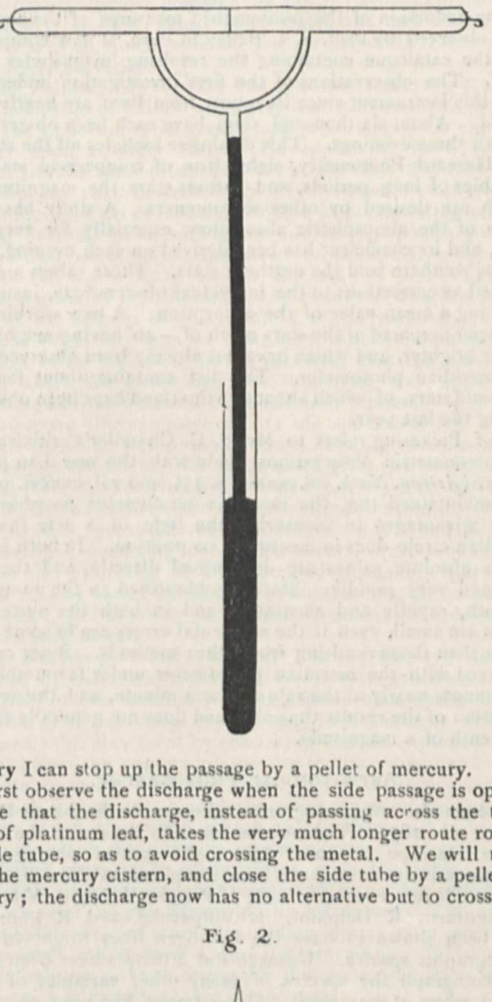
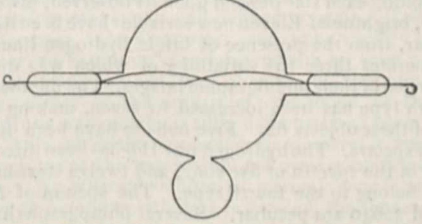


Fig. 2.



In the second experiment the metal diaphragm is replaced by a very thin plate of mica; when the side passage is opened the discharge goes round, but when this is closed by a pellet of mercury the discharge prefers to go across the mica than through the mercury.

[1] Lecture delivered at the Royal Institution by Prof. J. J. Thomson, F.R.S.

A second experiment which shows the same thing is the following. Two long electrodes are fused into a bulb, so that the tip of an electrode is a considerable distance from the place where it passes through the glass. We will now send an alternating discharge through the tube, and you will see, I think, that the discharge, instead of going straight across the short distance between the ends of the electrodes, goes from the tip of one electrode to the place where the other passes through the glass, thus staying as long as possible in the gas before passing into the metal. The appearance of the discharge shows that the positive electrode is at the end of the wire, the negative at the junction of the wire with the glass.

Another interesting example of the difficulty the discharge experiences in passing from gas to metal is the discovery made by Profs. Liveing and Dewar, that when the discharge passes through a gas containing a large quantity of metallic dust, the light from the discharge, when examined in the spectroscope, does not show any of the lines of the metal.

The difficulty which the positive electricity finds in passing from the gas to the electrode depends a great deal upon the nature of the gas, as well as upon that of the electrode; it is influenced by the position of the gas and the electrode relatively to one another in the electro-chemical series.

I have lately made a series of experiments on this point in the following way. An alternating discharge from a high tension transformer was made to pass between two electrodes fused into a bulb, which could be filled with the gases under examination. Another electrode connected to an electrometer, passed into the bulb, and was arranged so that it could be moved about from one part of it to the other. When the electrodes were metal and the bulb was filled with the electronegative gas oxygen, the electrode received a positive charge in whatever part of the bulb it was situated; if now the bulb was filled with hydrogen at atmospheric pressure, then in the regions remote from the arc the electrode received a positive charge, but in the immediate neighbourhood of the arc itself it received a negative charge. When the pressure was reduced the region in which the charge was negative contracted, and finally at pressures about one-third of an atmosphere, seemed to disappear, and the electrode got a slight positive charge in whatever position it was placed. If now, instead of using metallic electrodes we use well-oxidised copper ones, and repeat the experiment in hydrogen, working at a pressure when there was only positive electricity, when the electrodes were bright and polished, we find that with the oxidised electrodes every particle of positive electricity is taken out of the tube, and a negative charge is left. This negative charge remains until the copper oxide is completely reduced; when this occurs the negative charge disappears, and is replaced by positive. Thus, under the same conditions as to the nature of the gas and the pressure, the bright copper electrodes leave a positive charge in the gas, while the oxidised ones leave a negative charge.

The most probable explanation of these results seems to me to be the view that the communication of electricity from gas to the electrode, or from the electrode to gas, is facilitated by the temporary formation of something of the nature of a chemical compound between the gas and the metal. In all such compounds the metal is the electro-positive element, and has the positive charge, the gas being the electro-negative and carrying the negative charge. Now consider the case when the negative charge is on the gas, and the positive charge on the metal; then the gas and metal have got the charges proper to them in any compound they may form, and are thus in a fit state to combine, or according to this view, allow the negative electricity to pass from the gas to the copper. But, now, suppose the gas was positively electrified, the gas and the metal have now opposite charges to those proper to them in a compound, and before the union of gas and metal in this state could result in anything but a most unstable compound, an additional process must be gone through—*i.e.* the charges on the gas and metal must be interchanged. Thus the conditions for the combination of the gas and metal are more complex when the gas is positively electrified than when it is negatively electrified, and thus, on the view that the communication of electricity between the gas and the metal involves a sort of chemical combination, we see that the negative electricity will escape more easily from the gas to the metal than the positive. Now consider the case when the gas was hydrogen, the electrodes oxidised copper; the hydrogen combines now not with the metal, but with the oxygen, forming water, in which hydrogen is the electro-positive element; thus, in this case, it is the positively charged hydrogen which is in the state best fitted for pairing. The consequence is, the positive charge would be most readily removed from the gas and the negative left—exactly the opposite to that which occurred when the electrodes were bright. This reversal, as I stated before, is verified by experiment.

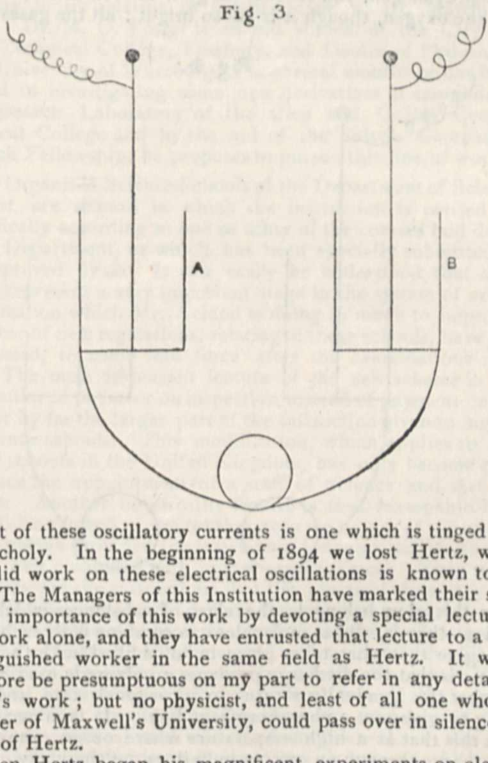
I have hitherto only spoken of the phenomena which accompany the passage of electricity from the electrode to the gas, or from the gas to the electrode.

I shall now pass on to consider the properties of the discharge when it is entirely confined to the gas.

We may produce a discharge which, during the whole of its course, shall be confined to the gas in the way represented in the diagram.

The two poles of a Wimshurst machine are connected to the insides of two jars A and B, while the outsides of these jars are connected together by a metal wire wound so as to form a coil. The electricity from the Wimshurst machine charges up the jars, the difference of potential between the poles increases until a spark passes. The passage of the spark puts the insides of the two jars in connection, and the jars are discharged. The discharge of the jar, as was proved from the theory of electromagnet action by Lord Kelvin more than forty years ago, and shortly afterwards confirmed by the experiments of Feddersen, is an oscillatory one, producing currents surging backwards and forwards through the wires with extraordinary rapidity. The

Fig. 3.




subject of these oscillatory currents is one which is tinged with melancholy. In the beginning of 1894 we lost Hertz, whose splendid work on these electrical oscillations is known to you all. The Managers of this Institution have marked their sense of the importance of this work by devoting a special lecture to this work alone, and they have entrusted that lecture to a most distinguished worker in the same field as Hertz. It would therefore be presumptuous on my part to refer in any detail to Hertz's work; but no physicist, and least of all one who is a member of Maxwell's University, could pass over in silence the death of Hertz.

When Hertz began his magnificent experiments on electric oscillations, there were many theories of electrical action. When he had finished them there was only one, Clerk Maxwell's.

Hertz's work was done with very much quicker vibrations than those produced by the apparatus now on the screen; this, however, gives rise to currents through the coil changing their direction some million times a second. If we place in the coil an exhausted bulb, the bulb in reality will be the secondary of an induction coil, and will be exposed to electromotive forces tending to produce circular currents parallel to the plane of the coil.

I will now place a bulb inside this coil, and you see that a circular ring discharge passes through it, and this discharge passes entirely in the gas.

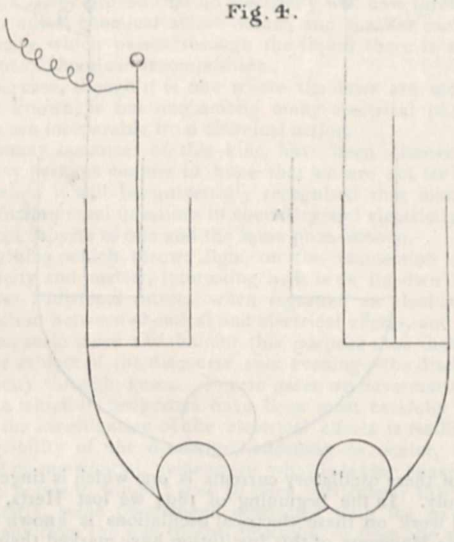
The gas in the bulb now in the coil is the vapour of silicon tetrachloride; it happens to be the bulb which gives a brighter ring than any others I possess.

If this ring discharge passes through air at different pressures, the colour of the discharge changes very considerably. The first bulb I put in was at fairly high pressure, about $\frac{1}{10}$ of a millimetre or so. I will now put in another at a lower pressure, and then one at a still lower pressure. Mr. Newall, who has been working at the spectra of these discharges, finds that at the pressure in the first bulb the spectrum is due to nitrogen; at the second stage it is due to mercury vapour; the bulb was pumped by a mercury pump, so that there is in the bulb a certain quantity of mercury vapour.

The apple-green colour in the more highly exhausted bulb is due to some compound of sulphur, which has got into the bulb from the sulphuric acid used to dry the gas. Mr. Newall finds that if the ordinary discharge from a coil between electrodes is taken in such a bulb, there is no trace of this sulphur spectrum. He has also found that when the bulb is at a pressure intermediate between what I may call the mercury and the sulphur stage, when the mercury and sulphur lines are both visible, these sets of lines come from different layers, the sulphur lines coming from a layer nearer the surface than the other.

If we take the discharge through a bulb containing oxygen, you will see that the ring discharge is succeeded by a bright glow; at first the colour is somewhat opaque, but gradually gets more transparent and changes colour. This gives a continuous spectrum crossed by a few bright lines. If we take the discharge through cyanogen, you see that the glow is even more persistent than the oxygen, though it is not so bright; all the gases which

Fig. 4.



show this glow belong to the class of substances which polymerise—that is, whose molecules can combine with each other. I imagine that what takes place in bulbs filled with these substances is that the discharge produces a polymeric modification, and that this gradually returns to its original state, and while doing so gives out a phosphorescent light. It is in accordance with this that at a high temperature where ozone cannot exist a discharge through an oxygen bulb does not show any glow.

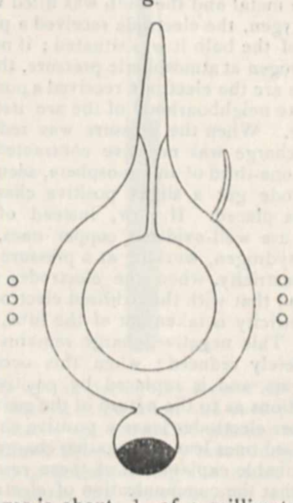
I said at the beginning of this discourse that gases were exceedingly good conductors of electricity. I will now endeavour to show an experiment which proves that statement. The apparatus which I shall use for this purpose is a slight modification of the one I have used for producing the ring discharge; the only difference is that in the wire connecting the two coatings of the jars there are two loops instead of one. In one of these loops an exhausted bulb is placed to serve as a kind of galvanometer; the brightness of the discharge is an indication of the strength of the current flowing round the coil. If I place a second conductor in the other loop, currents will be started in it, and part of the energy of the discharge will be absorbed; this will leave less energy available for the bulb in the first, so that the discharge in this bulb will be dimmer. The effect produced on the discharge will depend upon the conductivity of the substance placed in the second loop.

The effect is not directly proportional to the conductivity; in fact, a perfect conductor would not produce any diminution, nor would an absolute non-conductor; for a given period, and with apparatus of given dimensions, there is a certain conductivity which gives a maximum effect; this follows easily from the theory of induction of currents, but at this late period in the evening I will take a shorter course and prove it by an experiment.

I put a piece of brass in this loop, and you see it produces but a small effect upon the brightness of the discharge. Instead of brass I now insert a plumbago crucible, which, though a conductor, is not nearly so good a one as the brass, and you see the discharge in the indicating bulb is completely stopped.

I will now place in the second loop an exhausted bulb; you see it produces a decided diminution in the intensity of the discharge in the galvanometer bulb. I now replace the bulb by another of the same size containing dilute sulphuric acid; you see it does not produce nearly so large an effect as the exhausted bulb; this might be due, as we have seen, to the sulphuric acid being either too good or too bad a conductor. I can show that it is the latter by putting a bulb in filled with a stronger solution, which has a higher conductivity than the weak solution; if the smallness of the effect produced by the weak acid were due to its being a better conductor than the gas, then increasing the conductivity would still further diminish the effect of the acid; you see, on the contrary, that the strong acid produces a distinctly greater effect than the weak, hence the rarefied gas in the bulb is a better conductor even than the strong electrolyte. Let us consider for a moment the molecular conductivities of the two substances, the rarefied gas and the electrolyte. The

Fig. 5.

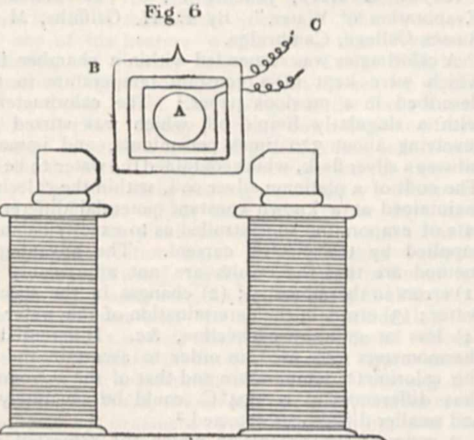


pressure of the gas is about $\frac{1}{100}$ of a millimetre, while in the electrolyte there are sufficient molecules of the acid to produce, if they were in the gaseous state, a pressure of more than 100 atmospheres; thus the conductivity of the gas estimated per molecule is about 10 million times that of the acid, this is greater than the molecular conductivity of even the best conducting metals.

If the pressure of the gas is diminished below a certain point, the conductivity begins to diminish. I have here an experiment which I hope will show this. The apparatus (Fig. 5) consists of two bulbs, one outside the other; the inner bulb contains air at a low pressure, while the space between the two bulbs is a very high vacuum containing practically nothing but a little mercury and its vapour. The amount of mercury vapour in this space is, at the temperature of the room, exceedingly small, but as the apparatus is heated the vapour pressure increases, and we are thus able to produce a fairly wide range of pressure in the space between the bulbs. The outer sphere is surrounded by the coil connecting the outer coatings of the two Leyden jars. When the space between the bulbs is a conductor, the alternating currents circulating in the coil will induce in this conductor currents whose inductive effect is opposite to that of the currents in the coil; and in this case this layer will screen off from the inner bulb the electromotive force due to the alternating currents in the coil. If, on the other hand, the space between the bulbs is a non-conductor, the inner bulb will be exposed to the full effect of these forces. We now try the experiment: you observe that when the mercury is cold, and consequently the pressure in the space between the bulbs very low, a bright discharge passes through the inner bulb, while the space between the bulbs remains quite dark; when we heat the mercury so as to increase the pressure of its vapour, a bright discharge passes through the outer layer, while the inner bulb is quite dark; the outer layer is now a conductor, and by its action screens off from the inner bulb the induction of the coil.

The last experiment I have to show is one on the effect produced by a magnetic field on the discharge. When the discharge has to flow across the lines of magnetic force, the pressure of the magnetic field retards the discharge; when, however,

Fig. 6




the discharge flows along the lines of magnetic force, the discharge is helped by the magnetic field. This is shown in the following experiment. A is a bulb; B a square tube, one side of which is placed between the poles of an electromagnet; the coil C, which connects the outside coatings of the jars, can be adjusted so that when the magnet is "off," the discharge passes through the bulb but not round the square tube; when, however, the magnet is "on," the discharge passes in the square tube but not in the bulb. In the square tube the discharge passes along the lines of magnetic force and is helped; in the bulb it passes across them and is retarded.

## UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—In a Convocation held on Tuesday, January 29, the degree of Doctor of Medicine, by decree of the House, was conferred on J. S. Burdon Sanderson, F.R.S., Regius Professor of Medicine. Prof. Sanderson was at the same time empowered to discharge the duties of the Waynflete Professor of Physiology, and to dispose of the income of the department during the vacancy in the Waynflete Professorship.

The amendments to the proposed form of statute on degrees for research will be submitted to Congregation on Tuesday, February 12. There are no less than sixty-three amendments, most of which are consequential. The chief amendments propose that the degree of Bachelor of Arts shall be substituted for the proposed degrees of Bachelor of Letters and Bachelor of Science; that the delegacy for the supervision of candidates shall be chosen from among a limited number of University officials, and that there shall be no such delegacy, but that the supervision shall be entrusted to the Boards of Studies.

The Sibthorpian Professor of Rural Economy will deliver an inaugural lecture on Monday, February 4, at 5.30 p.m., on "The Present Relations of Agricultural Art and Natural Science."

Mr. A. B. Trevor Battye will give a lecture before the Ashmolean Society on Monday, February 4, at 8.30 p.m., on his experiences in Kolguev Island.

The Vice-Chancellor has received for the University a bequest from the late Miss Susan Kidd of a portrait of her father, Dr. John Kidd, of Christ Church, formerly Regius Professor of Medicine.

CAMBRIDGE.—The Special Board for Biology and Geology propose that in future the Walsingham Medal, given by the Lord High Steward annually for biological research, shall be open to graduates of the University up to the standing of Master of Arts. Of the three Medals offered, two have been awarded—one for a zoological and the other for a botanical essay. It is also proposed that the Medal shall not be awarded twice to the same person.

The funeral of the late Prof. Cayley will take place on Friday, February 1, in Trinity College Chapel, and the Mill Road Cemetery. Members of the University desiring to be present, are requested to assemble in the College Hall at 1.45 p.m.

The Sedgwick Memorial Syndicate have been empowered to reconsider the plans, or prepare new ones, for the Geological Museum. The estimates for Mr. Jackson's plan exceeded the means at the disposal of the University.

Dr. L. E. Shore, St. John's College, has been appointed an additional member of the Medical Board. Dr. A. Ransome, F.R.S., Dr. J. L. Notter, Dr. T. Stevenson, F.R.S., and Dr. R. Thorne Thorne, C.B., F.R.S., have been appointed Examiners in State Medicine for the current year.

At the Matriculation on January 28, seventeen new students were entered. This brings the total for the present academical year up to 894.

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THE Executive Committee of the City and Guilds of London Institute have awarded the first Salters' Company Research Fellowship for the encouragement of higher research in chemistry in its relation to manufactures, to Dr. Martin O. Foster. Dr. M. O. Foster is an old student of the City and Guilds Technical College, Finsbury, and Doctor of Philosophy of the University of Würzburg. For several months he has been engaged in investigating some new derivatives of camphor in the Research Laboratory of the City and Guilds Central Technical College and by the aid of the Salters' Company's Research Fellowship, he proposes to pursue this line of work.

THE Organised Science Schools of the Department of Science and Art are schools in which the instruction is carried on methodically according to one or other of the courses laid down by the Department, or which has been specially submitted to and approved by it. It can easily be understood that such schools represent a very important stage in the system of scientific education which Mr. Acland is doing so much to improve. A number of new regulations, relating to these schools, have just been issued, to come into force after the examinations next May. The most important feature of the new scheme is the introduction of payment on inspection instead of payment on results, for by far the larger part of the instruction given in organised science schools. This modification, which applies to 120 science schools in the United Kingdom, has only become possible since the appointment of a staff of Science and Art inspectors. Another noteworthy feature is that reasonable latitude will be allowed to the teacher as to the nature of the course he may pursue provided the instruction is sound, satisfactory in amount, and combined with proper practical work. Even more satisfactory are the instructions that the practical chemistry for the first year's course should include the setting up of apparatus—weighing and other chemical manipulations, the preparation of gases, the estimation of volume, and so on. Analysis will, in future, occupy a secondary position in introductory courses. The mechanical test-tubing, which has hitherto formed the greater part of practical chemistry in Departmental schools, will thus give place to practical work of real educational value. We also observe that provision is made for a certain amount of literary instruction being given whilst the student is pursuing his science curriculum; that a choice of advanced courses is given; and that an alternative programme suitable for women is formulated, and instruction in subjects specially adapted to them is demanded; that practical instruction must be given in the subjects of science simultaneously with the theoretical instruction. Clearly, the new rules will greatly assist the development and better organisation of scientific education.

## SCIENTIFIC SERIALS.

*American Journal of Science*, January.—Late glacial or Champlain subsidence and reëlevation of the St. Lawrence River basin, by Warren Upham. From the Champlain submergence the Atlantic coast of North America was raised somewhat higher than now; and its latest movement from New Jersey to Greenland has been a moderate depression. As in Scandinavia, the restoration of isostatic equilibrium is attended by minor oscillations, the conditions requisite for repose having been overpassed by the early reëlevation of outer portions of each of these great glaciated areas. The close of the Ice Age was not long ago, geologically speaking, for equilibrium of the disturbed areas has not yet been restored.—An automatic mercury vacuum pump, by M. I. Pupin. This pump is a combination of a suction pump capable of raising mercury to practically any height, and an ordinary Sprengel pump, the two being connected by a siphon barometer. Mercury is pumped into the Sprengel reservoir by the suction pump. The reservoir of the latter is provided with two vertical tubes dipping into two mercury vessels. The end of one of these is higher than that of the other, so that when the mercury has fallen to the level of the end, no more mercury enters the tube, and the column already in it is bodily drawn up into the siphon barometer.—Graphical thermodynamics, by René de Saussure. The author recommends the adoption of new coordinates instead of P and V. Instead of these, he advocates the variables $\phi$ and $s$, defined by the equations $\phi = \pi/i^2$ and $s = \pi a^2$, where $i$ is the period and $a$ the amplitude of the vibratory motion constituting heat. Then the value of each variable depending upon the phenomenon can be obtained graphically.—Solutions of salts in organic liquids, by C. E. Linebarger. The law enunciated by Schroeder and Le Chatelier, that the solubilities at equal intervals from the temperature of fusion for different solid bodies and in different solvents are the same, although approximately true for the cases investigated by them, is not applicable to the case of inorganic salts in normal organic solvents.

*Wiedemann's Annalen der Physik und Chemie*, No. 13, 1894.—A new spectrum photometer, by Arthur König. Between the telescope and the collimator, which is provided with two parallel slits, are introduced, besides the refracting flint-glass prism, a twin prism and a Rochon polarising prism. One of the slits is provided with a total-reflection prism, in order to admit the standard light from the side. The field of view shows two semicircles, one for each of the sources of light, and their relative intensities can be adjusted and measured by a Nicoll prism near the eye. The observer notes the angle through which the Nicoll prism must be rotated in order to give equal intensities to the two halves of the field.—Spectra of various sources of light, by Else Köttgen. By means of König's spectrum photometer, various petroleum and gas lamps were spectroscopically studied.—On the process of light emission, by G. Jaumann. The author shows that the emissive vibrations of a luminous body exhibit a damping which may be measured.—Capillary electrometers and drop electrodes, by G. Meyer. The surface tension of mercury and some, but not all, amalgams is reduced by the addition of a solution of a salt of mercury, or of a salt of the metal contained in the amalgam. The reduction of surface tension which takes place during anodic polarisation is due to the formation of such mercuric or metallic salts.—Thermo-electricity of chemically pure metals, by K. Noll. This paper gives an account of a careful redetermination of the thermo-electric forces of pure Cd, Sn, Ag, Au, Cu, Zn, Al, Pt, Mg, Fe, Ni, Hg, and German silver.—Influence of magnetisation and temperature upon the electric conductivity of bismuth, by J. B. Henderson. The author shows that, before bismuth spirals can be employed to measure magnetic fields by their change of resistance, it will be necessary to find a ready means of testing their temperature, as the resistance is profoundly affected by changes in the latter.—High temperature thermometers of Jena glass No. $59^{III}$, by Alfons Mahlke. These thermometers have to be filled partly with liquid carbonic acid, after which they may be employed for temperatures up to 550°, the carbonic acid keeping the mercury from boiling. The author describes how he found the expansion of the glass and the mercury for such high temperatures, and calibrated one of the thermometers with reference to the air thermometer.

*Bulletin de la Société des Naturalistes de Moscou*, 1894, No. 1.—Contributions to the Moss flora of Russia, by Dr. Ernst Zickendrath, being an enumeration of 202 species collected by the author in European Russia proper (in German).—The formation of the primary blastoderms and the origin of the chord and the mesoderm in the Vertebrates, by B. Lwoff (in German, with six plates). A work which already has been partially published in *Biologisches Centralblatt* for 1892; it is based on the study of the embryology of the *Amphioxus*, the *Pteromyzon*, the *Axolotl*, the *Pristiurus* and *Torpedo*, several fishes and the *Lacerta*, and the author comes to the conclusion that the whole of the process is quite different from what is usually described as gastrulation. The paper is to be continued.—A general expression of the Thermodynamic Potential, by N. Oumoff.—Meteorological observations at the Petrovsk Agricultural Academy for the year 1893.

## SOCIETIES AND ACADEMIES.

### LONDON.

**Royal Society**, January 17.—"The Latent Heat of Evaporation of Water." By E. H. Griffiths, M.A., Sidney Sussex College, Cambridge.

A calorimeter was suspended within a chamber the walls of which were kept at a constant temperature in the manner described in a previous paper.[1] The calorimeter was filled with a singularly limpid oil, which was stirred by paddles revolving about 320 times per minute, and immersed in the oil was a silver flask, which contained the water to be evaporated. The ends of a platinum-silver coil, within the calorimeter, were maintained at a known constant potential difference, and the rate of evaporation so controlled as to exactly balance the heat supplied by the electric current. The advantages of this method are that the results are not appreciably affected by (1) errors in thermometry; (2) changes in the specific heat of water; (3) errors in the determination of the water equivalent; (4) loss or gain by convection, &c. Differential platinum-thermometers were used, in order to ascertain the equality of the calorimeter temperature and that of the surrounding walls, thus differences of 0·0004° C. could be accurately measured, and smaller differences detected.[2]

A series of experiments in which the saturated vapour was removed from the flask by a stream of dry gas, gave the following results.

| Temp. (Nitrogen Scale). | L (in terms of a thermal unit at 15°). |
|---|---|
| 24°·96 | 581·9 |
| 39°·99 | 572·4 |
| 49°·82 | 566·5 |

The method of experiment was then altered; rapid evaporation was caused by removal of pressure, and the mass of water evaporated determined in a different manner.

A considerable number of experiments gave the following results.

| Temp. (N. Scale). | Extreme values of L. | Mean L. |
|---|---|---|
| 30°.00 | 578·58 – 578·90 | 578·70 |
| 40°·15 | 572·12 – 573·01 | 572·60 |

The conditions as to rate of evaporation, &c., were varied greatly during the experiments.

The results are expressed by the following formula:

$$L = 596{\cdot}73 - 0{\cdot}6010\,\theta$$

This formula would give

$$L = 596{\cdot}73 \text{ when } \theta = 0^\circ$$

and

$$L = 536{\cdot}63 \quad ,, \quad \theta = 100^\circ.$$

And these values are almost identical with those obtained by Dieterici at 0° (596·73) and Regnault at 100° (536·60). A study of the results leads the author to the conclusion that the "thermal unit at 15°" must be almost identical with the "mean thermal unit between 0° and 100°." It has been shown by Rowland, by Bartoli and Stracciati, and by the author, that at low temperatures the specific heat of water decreases as the temperature rises, and it is probable that it arrives at a minimum between 30° and 40°, afterwards increasing with rise of temperature. There is, therefore, nothing impossible in the above supposition.

An investigation into the density of aqueous vapour (assuming the author's values of L and J) indicates that at low pressures the density of the saturated vapour is that of a perfect gas, and that at higher pressures (above 140 m.m.) it attains a density about 1·02 times as great as the "theoretical density."

January 24.—"Mathematical Contributions to the Theory of Evolution. II. Skew Variation in Homogeneous Material." By Prof. Karl Pearson, University College, London. (See p. 319).

1 "The Mechanical Equivalent," *Phil. Trans.* 1893 A, pp. 361–504.
2 See *Phil. Mag.* January 1895.

**Royal Microscopical Society,** January 16.—Annual meeting.—A. D. Michael, President, in the chair.—After the report of the Council for the past year and the treasurer's statement of accounts had been read and adopted, the President announced that the following were elected as officers and Council for the ensuing year:—President, A. D. Michael; vice presidents, Prof. L. S. Beale, F.R.S., Dr. R. G. Hebb, E. M. Nelson, T. H. Powell; treasurer, W. T. Suffolk; secretaries, Prof. F. Jeffrey Bell, Dr. W. H. Dallinger, F.R.S.; ordinary members of Council, T. D. Aldous, C. Beck, A. W. Bennett, Dr. R. Braithwaite, Rev. E. Carr. Frank Crisp, E. Dadswell, G. C. Karop, C. F. Rousselet, Dr. H. C. Sorby, F.R.S., J. J. Vezey, and T. Charters White. The President then delivered the address, the subject being, "The History of the Royal Microscopical Society." The President said that if any of his hearers would leave that West-end abode of science, and journey eastward to Tower Hill, and thence by Sparrow Corner along Royal Mint Street, he would find himself in Cable Street, St. George's-in-the East, not a very quiet or a very clean locality; turning down Shorter Street he would emerge opposite a space of green, where once stood the Danish Church, with its Royal closet reserved for the use of the King of Denmark when visiting this country; the space is surrounded by houses which have seen better days, and amongst them, between a pickle-factory and a brewery, stands a rather dilapidated erection which is 50 Wellclose Square; where, in 1839, lived Edwin J. Quekett, Professor of Botany at the London Hospital; and there, on September 3 of that year, seventeen gentlemen assembled "to take into consideration the propriety of forming a society for the promotion of microscopical investigation and for the introduction and improvement of the microscope as a scientific instrument." Among the seventeen were N. B. Ward, the inventor of the Wardian-case, which is not only an ornament to town houses, but was the means of introducing the tea-plant into Assam and the chinchonas into India, and who became treasurer of the society; Bowerbank Lister, who has been called the creator of the modern microscope; Dr. Farre, Dr. George Jackson, the Rev. J. B. Reade, and the enterprising and scientific nurseryman George Loddiges. Most of these subsequently became presidents of the Society. A public meeting was held on December 20, 1839, at the rooms of the Horticultural Society, then at 21 Regent-street, when the "Microscopical Society of London" was formally started. Prof. Richard Owen (not Sir Richard at that time) took the chair and became the first president, and shortly after the famous John Quekett became secretary, an office which he held almost to his death. At this moment Schleiden in Germany was commenting upon the paucity of British microscopical research, and attributing it to the want of efficient instruments, not knowing that a society was then forming which was to raise British microscopes to probably the first position in the world. The President then traced the history of the Society through the presidencies of Dr. Lindley the botanist, Prof. Thomas Bell the zoologist, Dr. Bowerbank, Dr. George Busk, Dr. Carpenter, Dr. Lankester, Prof. W. Kitchen Parker (all deceased), and of others equally famous who are still living; and showed how, under its influence and by its assistance, the vast improvements in the microscope, and the enormous extension of its use had gradually arisen; he also described its connection with the origin of the *Quarterly Journal of Microscopical Science*, the *Monthly Microscopical Journal*, and other publications, besides its own present widely circulated journal with its exhaustive summary of microscopical and biological work. He related how on John Quekett's death certain members of the Society subscribed to purchase for the Society's collection a curious microscope which Quekett possessed, and which had been made by the celebrated Benjamin Martin about 1770, probably for George III., and how they extended their subscription so as to provide a medal to be called "the Quekett medal" to be given from time to time to eminent microscopists; and how, difficulties having arisen, it happened that the only Quekett medal ever awarded was given to Sir John Lubbock. Finally, the President considered the future of the microscope and the prospects of further improvements. He said that many people were of opinion that the instrument is now perfect, and that consequently the most important *raison d'être* of the Society was over; he by no means agreed in that view, he believed that there was as much scope for progress in the future as there had been in the past; it was not by any means the first time that this idea had been put forward. In 1829 Dr. Goring, then a great authority on the subject, wrote in one of his published works: "Microscopes are now placed completely on a level with telescopes, and like them must remain stationary in their construction." In 1830, less than a year after, appeared Lister's epoch-making paper, "On the improvement of achromatic compound microscopes," and we have been improving ever since.—Mr. H. V. Tebbs proposed a vote of thanks to the President for his address; this, having been seconded by Prof. Bell, was carried.

EDINBURGH.

**Royal Society,** December 17, 1894.—The Hon. Lord M'Laren, Vice-President, in the chair.—Mr. Patrick Murray read an obituary notice of the late Mr. Donald Beith.—In a paper on germination in ponds and rivers, Mr. H. B. Guppy described observations on the germination of semi-aquatic and aquatic plants, and discussed the effects of temperature and light.—A paper on the Hall effect and some related actions in bismuth, by Mr. J. C. Beattie, was read. Mr. Beattie finds, with high fields, a reversal of the Hall effect in certain specimens of bismuth.—Mr. George Romanes communicated a paper on attraction treated by graphic processes, with deductions.

January 7.—The Rev. Prof. Flint, Vice-President, in the chair.—Dr. W. Peddie read a paper on a case of yellow-blue blindness, and its bearings on the theories of dichromasy. The historical aspect of the Young-Helmholtz theory is as follows: (1) Young gave his theory of colour-blindness by lapse of one sensation, stating that this seemed to him to be simpler than any other assumption. But, as with his theory of colour-vision, he meant this theory to be given up if it were subsequently found to be inconsistent with experiment. (2) Helmholtz added his ideas regarding the nature of the mechanism, adopting *implicitly* Young's reservations, and stating *explicitly* that his ideas, if false, did not affect the basis of Young's theory. (3) In accordance with the above facts, when E. Rose brought forward the evidence of his observations, Helmholtz at once indicated the probable direction in which the statement of the theory had to be modified. (4) Subsequently, Helmholtz's pupils, König and Dieterici, working presumably under his direction, made a crucial test to find if it were absolutely essential to abandon the idea of lapse of a fundamental sensation, and found that it was necessary to do so. (5) König investigated, at different parts of the spectrum, the mean error of wave-length which could be made in adjusting light from different near parts of the spectrum to equality. (6) Helmholtz gave an expression, in terms of the unknown fundamentals, for the rate at which the total "sensation" varies with wave-length. He wrote down three linear equations, with unknown coefficients, expressing the three fundamental sensations in terms of those chosen (arbitrarily so far) by König and Dieterici. The latter were known in terms of the wave-length by means of the observations of these two investigators. Therefore, if Helmholtz could determine the unknown coefficients, he could express the other fundamentals in terms of the wave-length. Now an obvious assumption to make is this: the mean error of wave-length which can be made in adjusting two very narrow strips, one from each of two similar spectra, to apparent equality corresponds to a constant difference of total "sensation." Helmholtz made this assumption in order to determine the unknown coefficients by means of König's observations on the mean error. And he further justified this by showing that there was a close correspondence between the mean errors found by König and the mean errors calculated from his own theory on the assumption of a constant difference of sensation. Thus the new fundamentals, given by Helmholtz as "provisional," may be regarded as having been determined upon a purely experimental basis, with no assumption other than the radical assumption of three fundamental sensations. The whole thing is a beautiful example of the cautious, steady, scientific development of a theory. There has not been, by Helmholtz, any violent upholding of a weakened theory, followed by a sudden facing round after defeat. In violet, or yellow-blue, blindness, the two colours of the spectrum are red and bluish-green, and the spectrum is shortened at the blue end with a sharp limit near the line G. Blindness of this type is rare. The case described in this paper presents the peculiarity that there is no shortening of the spectrum at either end. The range extends beyond the line *a* at the red end, and beyond the line H at the violet end. The neutral point is near the line D, on the more refrangible side. The maximum intensity of the red colour is reached at a point near C on the less refrangible side, and the maximum intensity of the green colour is reached at a point rather nearer to F than the mid-distance from *b* to F. There is no second neutral point in the blue. It does not seem that the phenomena can be readily, if at all, accounted for on Hering's theory. On the other hand, it is easily accounted for on the Young-Helmholtz theory by fusion of the fundamental sensations.—Dr. Noël Paton read a paper, by Dr. John Douglas, on metabolism in thyroid feeding.—Dr. Richard Berry read a paper on the anatomy of vermiform process and cæcum.—Prof. Tait communicated a paper on the ultimate state of a system of colliding particles, and the rate of approach to it.

PARIS.

Academy of Sciences, January 21.—M. Marey in the chair.—On the variable star $\beta$ (Algol) in Perseus, by M. F. Tisserand. The author represents the variation in apparent magnitude as being due to (1) the existence of one obscure satellite with an elliptical orbit, and (2) a slight oblateness of the principal star, and shows that on these assumptions the variation periods can be satisfactorily represented (see "Our Astromical Column").—On boron steel, by MM. H. Moissan and G. Charpy. As the result of a series of comparative tests, it is found that boron (0·58 per cent. in alloy used) imparts the property of a great increase in tensile strength by tempering without a corresponding increase of hardness. A sample of carbon steel giving similar increase of tensile strength on tempering, became so hard as to require working on the emery-bob, whereas the boron-steel could still be worked with a file.—Morphology of the lymphatic system. On the origin of the lymphatics in the skin of the frog, by M. L. Ranvier.—On the perforation of armour-plates, by M. E. Vallier.—On the production of the glycolytic ferment, by M. R. Lépine. The author is of opinion that the glycolytic ferment is produced from diastase. He relies on the increase of glycolytic power of pancreas when treated with dilute sulphuric acid, in conjunction with the loss of saccharifying power and gain of glycolytic power suffered by maltine when similarly treated with dilute acid.—*Résumé* of solar observations, made at the Royal Observatory of the Roman College, during the three last quarters of 1894. A letter from M. P. Tacchini sent to the President.—On the convergence of determinants of infinite order and of continued fractions, by M. H. von Koch.—Influence of the rhythm of successions of interruptions on the sensitiveness to light, by M. Charles Henry. The investigation had for object the determination of the sensitiveness of the eye to interrupted light-rays of different types. The conclusion is drawn that it is possible to augment the luminous range of a signal by means of a succession of interrupted rays following a sufficiently complex non-rhythmic law.—Influence of temperature on the transformation of amorphous zinc sulphide, by M. A. Villiers.—Failure of the Kjeldahl method for estimation of nitrogen when applied to chloroplatinates, by M. Delépine. In the cases of trimethylamine and ammonium platinochlorides, the author finds by the permanganate modification of the Kjeldahl process a considerable deficiency in ammonia obtained. This deficiency is attributed to a reaction of free chlorine with the ammonia, as follows:

$$(NH_4)_2PtCl_6 + 3Cl_2 = PtCl_4 + 8HCl + N_2.$$

—On arabinochloral and xylochloral, by M. Hanriot.—A new synthesis of anthracene, by M. Delacre. Anthracene is produced from benzyl trichloracetate and benzene, by heating these substances in presence of aluminium chloride, and distilling the resultant ether, when it decomposes giving carbon dioxide and anthracene.—A contribution to the study of the ethereal salts of the tartaric acids, by MM. Ph. A. Guye and J. Fayollat. A study of the rotatory power of nine of these esters in the light of the theory of the product of asymmetry.—On a parasite of *Lampyris splendidula*, by M. A. Gruvel. The author names the newly-described parasite *Stylogamasus lampyridis*.—On some bacteria from the *Dinantien* (Culm), by M. B. Renault. —On the development of sieve-tubes in the Angiosperms, by M. Chauveaud. The author concludes that (1) the rule of indirect development of sieve-tubes is far from general. Both direct and indirect methods of development may occur in the same bundle. (2) The presence of companion-cells is not absolutely characteristic of the sieve-tubes of Angiosperms.—On the Chili-Argentine earthquake of October 27, 1894, by M. A. F. Noguès.—Note on *Uredo viticida*, by M. L. Daille.

## BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—A First Step in Euclid: J. G. Bradshaw (Macmillan).—Memoir of Sir Andrew Crombie Ramsay: Sir A. Geikie (Macmillan).—A Handbook to the British Mammalia: R. Lydekker (Allen).—The Great Problem of Substance and its Attributes (K. Paul).—A Travers le Caucase: E. Levier (Neuchatel, Attinger).—Forschungsberichte aus der Biologischen Station zu Plön: Dr. O. Zacharias, Theil 3 (Berlin, Friedländer). —How to Live in Tropical Africa: Dr. J. Murray (Philip)—Field and Garden Crops of the N.W.P. and Oudh: J. F Duthie, Part 3 (Roorke).

PAMPHLETS.—Sur la Nature et l'Origine de l'Aurore Boréale: A. Paulsen (Copenhague).—Der Logische Algorithmus: J. Hontheim (Berlin, Dames).—International Beginnings of the Congo Free State: Dr. J. A Reeves (Baltimore).

SERIALS.—Journal of the Sanitary Institute, January (Stanford).—National Geographic Magazine, December 29 (Washington).—Transactions of the American Institute of Electrical Engineers, November and December (New York).—Imperial University, College of Agriculture, Bulletin Vol. ii No. 3 (Tōkyō).—Records of the Botanical Survey of India, Vol. i. Nos. 3 and 4 (Calcutta).—Psychological Review, January (Macmillan).—Monist, January (Chicago).—Himmel und Erde, January (Berlin).—English Illustrated Magazine, February (Strand).—Sunday Magazine, February (Isbister).—Good Words, February (Isbister).—Astrophysical Journal, January (Wesley).—Longman's Magazine, February (Longmans).—Chambers's Journal, February (Chambers).—Observations Internationales Polaires, 1882–3. Expédition Danoise, Observations faites a Godthaab, tome i. livr. 2 (Copenhague).—Humanitarian, February (Hutchinson).—Natural Science, February (Rait).—American Naturalist, January (Wesley).—Journal of the College of Science, Imperial University, Japan, vol. vii. Parts 2 and 3 (Tōkyō).—Transactions of the Linnean Society of London, Vol. iv. Part 2, On the Flora of Mount Kinabalu in North Borneo: Dr. O. Stapf (Linnean Society).—Ergebnisse der Beobachtungsstationen an den Deutschen Küsten über die Physikalischen Eigenschaften der Ostsee und Nordsee und die Fischerei, Heft 1–6 (Kiel, Lipsius).

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