THURSDAY, APRIL 27, 1899.

A HISTORY OF PHYSICS.

A History of Physics. By Prof. Florian Cajori. Pp. viii + 322. (London : Macmillan and Co., Ltd., 1899.)

IT is a formidable undertaking to write a book on the history of physics beginning with the dawn of science and including helium and Röntgen rays, and the task does not become easier when the whole has to be condensed into the narrow limits of 300 pages. We possess a number of more extensive histories, such as Heller and Rosenberger, and a few most valuable biographies of eminent men. These are boiled down into the present volume, which is readable and generally accurate, but is too slight and superficial to serve any useful purpose. The study of the history of science is of the greatest importance to the scientific man, and in addition, it is, when properly treated, a most fascinating study ; but when we come to estimate the value of any particular treatise, we must ask ourselves what it is precisely in the historical treatment that interests us. For when we wish to boil down our information we must know what has to be retained and what may be rejected, or else we should commit the error of imitating the manufacturer of meat extracts, who retains only the gelatine and water. That is, in my opinion, what Mr. Cajori has done. It may be his misfortune rather than his fault that the editor of NATURE has entrusted this review to me ; but having always taken a considerable interest in historical questions, I must acknowledge the author's reading and learning while I question his judgment. That, of course, may be a matter of opinion. The value of historical studies seems to me to lie in two directions. It is of high interest to follow out the evolution of thought, the gradual development of ideas, from the first suspicion of a new truth to its final experimental proof or mathematical demonstration. The way especially in which the same idea constantly originates simultaneously in different minds, and the question how far the different view often adopted by different nations is purely a matter of education, or has some deeper cause, has never yet been fully developed.

But, quite apart from this, every reader of original papers knows how many points are always missed by subsequent writers, and how clear ideas are only obtained by a study of original sources. If, for instance, we only know Faraday, or Maxwell, or Hertz through modern text-books, however good these may be, we shall miss a large number of important suggestions. Led by these considerations, Prof. Ostwald has originated the reprinting of important treatises under the name of "Klassiker der exacten Wissenschaften," and in the announcement of this publication has regretted the neglect of historical studies.

Curiously enough, Prof. Cajori quotes this regret of Ostwald's, and expresses the hope "that the survey of the progress of physics here presented, may assist in remedying this defect so clearly pointed out by Prof. Ostwald." As a matter of fact, Ostwald's remedy for what he terms the "absence of the historical sense," lies in the reading of original memoirs, while Prof. Cajori's cure lies in the prescription of small homœopathic globules intended to contain the concentrated concoction of all that is essential ; but whether this intention can be realised or not is exactly what is open to doubt. I must justify the opinion I have expressed by a few examples of Prof. Cajori's style and manner of treatment. I take in the first instance the reference to the second law of thermodynamics.

"In February 1850, Rudolph Clausius (1822 – 1888) communicated to the Berlin Academy a paper on the same subject, which contains the Protean second law of thermodynamics : 'Heat cannot of itself pass from a colder to a hotter body.' . . . In March 1851, there appeared a paper by Wm. Thomson, which contained a perfectly rigorous proof of the second law. He obtained it before he had seen the researches of Clausius. The statement of this law, as given by Clausius, has been much criticised, particularly by Rankine, Theodor Wand, P. G. Tait and Tolver Preston. Repeated efforts to deduce it from general mechanical principles have remained fruitless. The science of thermodynamics was developed with great success by Thomson, Clausius, and Rankine. As early as 1852, Thomson discovered the law of dissipation of energy, discovered at a later period also by Clausius."

Apart from the fact that Clausius' paper of 1850 does not either contain the words quoted, nor any reference to a second law at all (though the substance of it is given in the paper), one would like to know to whom the information given in the passage can be of any use. If a student possesses no knowledge of thermodynamics, he will not be any the wiser by it ; and if he does, he must have read books, such as Maxwell's "Theory of Heat," or Baynes' "Thermodynamics," and in any of these he will find much more ample and accurate historical references than those given by Mr. Cajori. In the same way throughout the book, the author generally does not go beyond what ought to be, and often is given in the ordinary text-books. As an example how short statements, though correct, often convey incorrect ideas, I give the account of the historical evolution of the ohm :

"In 1861 the British Association and Royal Society of London appointed a committee, with Lord Kelvin at its head, to recommend a unit ('B.A.' unit). Weber's absolute unit of resistance, was a velocity. The British committee adopted this unit in principle. . . . The securing of a convenient unvariable resistance equal to 10^9 absolute units has been a difficult task. The B.A. unit was a little too small. The 'legal ohm' was provisionally adopted in 1883, by a committee appointed by the congress of 1881. It was the resistance at 0° C. of a column of mercury, 1 square millimetre in cross section and 106 centimetres long. Competent investigators, like Rayleigh and Mascart, contended that this column was a little too short, but some smaller values obtained by certain experimenters led to the adoption of the mean value of 106 centimetres. The 'legal ohm' satisfied no one, and failed to become legal in any country.

"Henry A. Rowland, after pointing out errors in some of the determinations previously made, found the length of the mercury column in question to be 106·32 centimetres."

As a matter of history, Rowland's paper of 1878, which is not mentioned, is of much greater importance than the later one, because it drew attention to the inaccuracy of the original determination of the British Association. There is no reason why Rowland's later investigation,

published jointly with Kimball in 1884, should be singled out in the above passage, while Rayleigh is patronised as a "competent investigator."

In the history of the earlier times Prof. Cajori has followed good guides, such as Whewell and Mach; and though here also the space is entirely inadequate to give a sufficient account of the subject, we like this portion better than his treatment of contemporary science.

That there should be omissions was inevitable, but it might have been thought that the kinetic theory of gases was of sufficient importance to justify a short paragraph, while the only reference to that theory is to be found in the statement that a mathematical investigation of the radiometer action was given by Clerk Maxwell. Here again, as a matter of history, it was the discussion between Osborne Reynolds and Johnstone Stoney, not alluded to in the book, which brought about the correct explanation of the radiometer, and however important Maxwell's paper may be, it only appeared when the matter was cleared up. In a detailed historical account it is often necessary to allude to scientific squabbles and unpleasant discussions, but the author of this book might well have pleaded want of space, and omitted, for instance, such a passage as this: "William Thomson and Tait, placing a much lower estimate on Mayer's researches, brought the charge that Tyndall was belittling the work of Joule." I have marked several passages which are open to criticism, but it is not my intention to find fault with the details of a book which, as a whole, is perhaps as well done as could possibly be. It is the whole attempt to collect isolated facts in the belief that these constitute a history that seems to me to be mischievous. This does not, however, exclude the fact that most readers will probably find in the book some things they did not know before, and some useful references. ARTHUR SCHUSTER.

OUR SEA FISHERIES.

The Resources of the Sea, as shown in the Scientific Experiments to test the Effects of Trawling and of the Closure of certain Areas off the Scottish Shores. By W. C. M'Intosh, M.D., LL.D., F.R.S., &c. Pp. xvi + 248, and Tables. (London: Clay and Sons, 1899.)

IT is well known that at the time of the late Lord Dalhousie's Royal Commission on Sea-Fisheries (1883–85) Prof. M'Intosh conducted, for the Commission, a series of most important trawling investigations off the coast of Scotland which formed the starting-point of a good deal of the experimental and observational work of the Fishery Board for Scotland—work which has been noticed from time to time in the columns of NATURE during the last ten or twelve years. The book before us is practically devoted to the summing up of that work and the discussion of its results, and there is no one probably who has a better right to do that than Prof. M'Intosh, who, by his trawling investigations in 1884, suggested the experiments of the Board, and who himself may be said to have superintended and controlled the work while acting as scientific member of the Board from 1892 to 1895—when he was succeeded by Sir John Murray. All this gives additional importance to the fact that Prof. M'Intosh now declares against the policy of the Fishery Board, criticises their methods and their conclusions as published in recent annual reports, and is apparently in favour of removing all restrictions upon fishing, and of throwing the territorial waters open to trawlers and liners alike.

It is clear, then, that the book deals with debatable matters, and probably few fisheries experts will agree with the author in all his points. The work is happily named the "Resources of the Sea," as the central idea running all through it is that marine animals and plants have such extraordinary powers of reproduction as to be practically unaffected by the influence of man; while the secondary title shows that it is the trawling experiments and the results of closure of sea-areas off the coast of Scotland that are specially discussed and criticised.

There is an "Introductory" chapter, giving a general review of marine life, with most of the statements in which every biologist will agree. It may be remarked, however, that the vast possibilities of increase which may be true of diatoms and many groups of lower animals, and even of some fish, are not necessarily true of all kinds of food fishes in the inshore waters. The plaice and the sole are probably in this respect in very different case from the herring, the cod, and the oft-quoted haddock.

Prof. M'Intosh next gives us a chapter dealing with the effects of trawling, and of the hooks of liners, upon the food, the eggs and the young of our fishes; the present state of the fishery steamers and their apparatus, and upon the method in which the Fishery Board for Scotland have carried out the recommendations of the Trawling Commission. In all of this there is naturally a good deal of evidence to show that the trawlers do not do the harm to the sea-bottom that has been from time to time ascribed to them; and we readily agree with the conclusion on p. 50:

"A calm survey of the situation, therefore, does not lend support to the notion that the trawl, as ordinarily employed in sea-fishing, is the only destroyer of the invertebrate animals of the bottom; and, further, experience does not demonstrate that the sea-bottom in any known region has been, by the use of such line or trawl, so seriously impoverished as to be unable to support fish-life."

Some of us are unable, however, from what we know on other coasts, to endorse the further opinion that trawling does no great damage to the young food-fishes on the bottom. Our experience in Lancashire is that grave destruction of immature flat-fish is caused by trawling in the "nurseries" along the shallow sandy shores; and that in protected areas, such as the closed ground off Blackpool, a rapid increase of the more sedentary flat-fish takes place. We fail to understand the statement[1] on p. 234, that closure is powerless to prevent such destruction.

Prof. M'Intosh then takes up, one by one, the sea-areas which have been closed against trawling by the Fishery Board, and in which experimental hauls have been made from time to time by the Board's small steamer, the *Garland*. Unfortunately that vessel is too small for the work; we labour under a similar dis-

[1] "The capture of great numbers of small fishes by either trawlers or liners is a misfortune for the country, but the closure is powerless to prevent it." This requires further explanation.

advantage in Lancashire. A Fishery Board or Committee carrying on scientific and experimental work ought to have a vessel that can go to sea and stay at sea in all ordinary weathers, and that can follow the fishing fleets and work with them on equal terms. That is not possible for either the *Garland* or the *John Fell*.

Chapters are devoted to the trawling experiments in St. Andrews Bay, in the Firth of Forth, in the Moray Firth, and in the Firth of Clyde; and in each case it is argued that the closure has effected no change, that there has been no great increase in the fish population, and that, on the other hand, there has not been that decrease which the Board have recently made a reason for wishing to obtain control of the fishing on the offshore spawning grounds. But it seems pretty clear, from the detailed analysis given of the statistics, that the observations are not really sufficiently numerous and sufficiently trustworthy to justify any general conclusions. We are constantly reminded of the smallness of the steamer and the inefficiency of her trawl.[1] Prof. M'Intosh himself evidently distrusts the results, and speaks more than once of the "uncertainty." The observations, moreover, were not always taken in the same months, and so certain series of the statistics cannot fairly be compared. It is curious that the results obtained from the "closed" and the "open" areas have not been treated quite separately in the tables. Surely in a discussion of the effects of closure it would have been safer to have rigidly excluded the statistics not obtained wholly from closed grounds.

Nor is it quite clear to us that Prof. M'Intosh is convinced by the evidence he brings as to the abundance of fish in our seas. Here again one ought to clearly distinguish between the more oceanic and active fishes, such as the herring and haddock, which come and go and are largely beyond man's control, and the more local and sedentary forms, such as most of the valuable flat-fish. In regard to the latter, much evidence has been given from time to time in regard to different parts of our coast, showing the depletion of certain areas. It is curious, in this connection, that Prof. M'Intosh, while quoting freely from the work of the Trawling Commission of 1883 and of the earlier Commission of 1878,[2] makes no allusion to the evidence given before the much more recent Select Committee of the House of Commons in 1893, the statements in Mr. Calderwood's paper on "British Sea-Fisheries, &c." (1894), and other recent works. It is doubtful whether the older opinions are of much value now under the new conditions. The fishing methods have been so entirely changed with the introduction of powerful steamers and otter-trawls, and the area fished has been so enormously extended during the last few years, that no argument can safely be drawn as to the fish population of our own coastal waters from the supply landed for the markets.

In the discussion of statistics like these so much depends upon the grouping of the figures, and upon the comparisons made, that I for one should not be at all surprised if Dr. Wemyss Fulton, the scientific secretary of the Fishery Board, succeeded from the same series of figures in establishing what we may take to be his main contention that, as a result of the closure there has been a diminution of plaice and lemon soles, and a marked increase of common and long rough dabs, *in the closed areas*. We are afraid, however, that the statistics collected so far are insufficient, and that it is premature as yet to draw any conclusions. And that is the reason why some of us think it important that the Fishery Board's experimental work should not be stopped at this stage. Although ten or even fifteen years may have been spent—and much money—still if reasonable doubt remains, if it seems that more extended experiments might give other and more definite results, surely this is not the time to reverse the policy and stop the accumulation of statistics.

We have reason to think, moreover, from information obtained outside the official reports, that in the Clyde at least the closure is resulting in an increase of the flat-fish on the ground. In the spring of 1887, as the result of their trawling experiments, the Board stated that "the flat-fish in the Clyde are only about half as numerous as in the Forth at the same period of the year," and they considered this as evidence of depletion. In the spring of 1898, after the decade of protection, the Lancashire Fisheries' steamer *John Fell*, trawling during three days for scientific purposes, by special permission of the Board, found what the experienced fishermen on the ship, accustomed to the fishing grounds of the Irish Sea, considered to be rich accumulations of flat-fish, including many true soles (*Solea vulgaris*). The very fact that poaching goes on is sufficient to show that the fishermen regard the closed areas as desirable trawling ground with an abundant fish population.

Well, there are the two policies: the one to preserve these fish sanctuaries by means of restrictions which cause constant friction, and which we would all prefer to see removed; and the other to add more or less artificially to the population of the sea by hatching, or by returning fertilised spawn to the water. The Board is at present pursuing both policies, and it may be that both are necessary.

As the book before us is mainly directed against restrictive measures, we are glad to see at the end of it, in the "Summary," some words as to the natural alternative, "productive" measures; and we can cordially agree with the remarks on p. 231, in regard to hatching. Some years ago (December 1894), Prof. M'Intosh wrote an interesting article on the subject in *Science Progress;* a few months ago, in a letter to the present writer, he said, in regard to sea-fish hatcheries:

"Of course such institutions are strictly experimental, and it may be some time before a decisive result is evident. Meanwhile, work them thoroughly and support them liberally."

This is what the Fishery Board are doing at Dunbar and at Aberdeen, and what we in Lancashire are now doing at the Piel hatchery. At the conclusion of the present book Prof. M'Intosh repeats his former statements, and urges that support should be given to such experiments "till the issue is clear."

[1] This must not be regarded as any reflection upon the scientific work of the Scottish Fishery Board, or upon much other useful work accomplished by Dr. Fulton and the staff on board the *Garland*.

[2] By the way, why is "the late Mr. Spencer Walpole" (*sic*) not referred to under his present title of Sir Spencer Walpole, K.C.B.?

I cannot refrain from drawing attention to the fine ideal of the scientific man's action in regard to the fisheries which our author holds up to us. I quote from p. 223:

"A close observer of nature, he weaves no theories, and is not incautious in deduction. The welfare of the fisheries as a whole is his aim, and the influences which act on those engaged financially in them, or have political or other connections with them, are unknown to him."

Prof. McIntosh's friends may be permitted to add that he himself realises that ideal more nearly than any one else we know in the field.

The book is charmingly illustrated with views of the marine laboratory, the harbour, the boats, and some characteristic features of fishing life in the celebrated old Scottish university town of St. Andrews, which the fame and long-continued labours of McIntosh have done so much to render a "Mecca" to the young marine zoologist. W. A. HERDMAN.

OUR BOOK SHELF.

The Lepidoptera of the British Islands. A Descriptive Account of the Families, Genera, and Species Indigenous to Great Britain and Ireland, their Preparatory States, Habits, and Localities. By Charles G. Barrett, F.E.S., one of the Editors of the *Entomologist's Monthly Magazine*. Vol. V. Heterocera: Noctuæ. Pp. 381. (London: Lovell Reeve and Co., Ltd.)

IN the present volume, Mr. Barrett discusses 111 species of British Noctuæ, in the same elaborate manner as in the volumes which we have previously noticed. He has long been recognised as one of our best living authorities on the British *Lepidoptera*, and his book will remain of great and permanent value as a record of the state of this branch of our fauna as it exists at the end of the present century. Among the most interesting moths here noticed are those which are attached to the Fens, several of which are now very much scarcer than formerly in England, though some species (such as *Tapinostola concolor*, Guen.), which were supposed to have become extinct, have now been rediscovered in other localities; while several Fen species, quite unknown during the palmy days of the Fens, have lately been discovered there. We have heard it suggested that this may be due to fresh localities in the Fens having been made accessible by drainage; but in the case of *Calamia brevilinea*, Fenn, Mr. Barrett remarks: "It seems to furnish all the evidence which it would be possible to obtain, in order to suggest the actual genesis, or introduction of a total novelty, to the world's fauna." It appears that the exact locality where the insect now occurs was well worked in 1857, without its being discovered; but in 1864 the first specimen was taken, and no more till 1871, when a few specimens were taken, after which, it has become both commoner and more widely spread in the Fens, and a single specimen has been taken in Belgium. The remarks on the habits of various moths, especially, perhaps, their behaviour at sugar, &c. (under the notice of *Taeniocampa gothica*), will also be read with interest. The well-known cannibal habits of the larva of *Cosmia trapezina* are also remarked on. It should be observed that this work is issued in two editions—one with, and the other without, plates.

W. F. K.

An Introduction to the Mathematical Theory of Attraction. By Francis A. Tarleton, Sc.D., LL.D. Pp. xii + 290. (London: Longmans, Green, and Co., 1899.)

THE author tells us that his object is to make the acquisition of a competent knowledge of the theory of attraction as easy as possible for the student. With this view he has given, in addition to the theorems on attractions and potential to be found in most of the text-books, an account of the theory of electrostatics and some outlines of the theory of magnetism. He has attended almost exclusively to the mathematical view of his subject. Possibly the students for whom he writes will have formed sound physical conceptions before they begin to read his book; in that case they will probably find in it what they want in the way of mathematical theory.

To indicate the scope of the book, we may observe that it contains such things as the determination of the attraction of an ellipsoid by direct integration, Laplace's equation in elliptic coordinates, the distribution of electricity on a freely charged spherical bowl, and Kirchhoff's theory of the distribution on two spheres. A student for whom these things are not too difficult could appreciate many things that are omitted, such as the potential of a magnetised body of finite size, Laplace's equation in orthogonal curvilinear coordinates and the logarithmic potential in three dimensions. The author has done well in refraining from barren discussions of artificial laws of force differing from that found in nature.

The plan followed, viz. that of treating gravitational attraction and electrostatic and magnetic forces together, has the disadvantages that the standard case of attraction is repulsion and that special units have to be used in treating gravitation; it has the advantage that it tends to break down the system of water-tight compartments in which students always store their knowledge. A number of results that might be more simply obtained by indirect methods are obtained by direct integration. The potential is introduced comparatively late, the definition even being postponed to the fourth chapter. One excellent feature of the book is that two-dimensional problems and three-dimensional problems are treated separately and side by side.

The author's mathematical methods are the traditional ones of British text-books, except that here and there he presents investigations by Mr. Purser. But surely it is time that writers of books, even on applied mathematics, took some account of modern developments of analysis. If an exhaustive discussion of the existence theorem would be out of place, it would yet seem not unreasonable to expect the banishment of such banalities as "consecutive points" and "infinitely small quantities," the avoidance of meaningless equations between divergent series and divergent integrals, the presentation of a proof that the convergent integrals which represent the components of attraction at a point within an attracting mass are the differential coefficients of the convergent integral which represents the potential at such a point, a little care in extending Gauss's theorem concerning the surface integral of normal force from a single particle to a distribution of density, some discussion of the discontinuity of the second differential coefficients of the potential at the boundary of an attracting body. Why write a new book which follows the old ones in leaving undone the things that ought to be done, and doing the things that ought not to be done?

The book contains several interesting collections of examples. These should prove useful to teachers as well as to students. A. E. H. L.

Outlines of the Earth's History; a Popular Study in Physiography. By Nathaniel Southgate Shaler. Pp. viii + 418. (London: William Heinemann, 1898.)

IN these outlines Prof. Shaler has felt the necessity of selecting certain features of the history of the earth for comparatively full treatment in order to supply a more helpful aid to a true knowledge of the earth than is afforded by the "ordinary text-books." At first sight the selection appears inadequate and arbitrarily proportioned. The seven chapters devoted to the concrete subject (after thirty pages of introductory matter) are entitled "The Stellar Realm," "The Earth," "The

Atmosphere," "Glaciers," "The Work of Underground Water," "The Soil," and "The Rocks and their Order." Closer examination, however, shows that these headings are texts for exposition rather than descriptive titles, and a great variety of unexpected information is brought out in the course of the discussions, which are not cramped by an undue effort after conciseness of expression. Thus the Stellar Realm includes a description of the solar system, in which, incidentally, the fact that a planet always keeps the same face turned towards the body around which it revolves, is implied to prove that it does not rotate on its axis. The chapter on the Atmosphere embraces almost as much as the atmosphere itself: not only a little on climate and a great deal on storms, but all that is said about the oceans, tides, lakes and rivers is included under this head; yet glaciers have a chapter to themselves. The greater part of the "Work of Underground Water" is devoted to the phenomena of volcanoes, while earthquakes are dealt with apart under "The Rocks and their Order," a chapter which also includes a section on the moon.

The whole is written in a thoroughly interesting style, like all Prof. Shaler's work, and the frequent references to his own researches give it an element of personal attractiveness. He mentions that, in spite of his long study of swamps, he never saw the phenomenon known as Will-o'-the-Wisp, and is inclined to disbelieve in its existence; the reports of a moving light being, in his opinion, due to subjective impressions induced by gazing into darkness.

But although an interesting book to read, and one which is likely to attract the reader to more systematic scientific studies, this work seems to leave an opportunity for honest doubt as to the wisdom of piecing together portions of discussions unequal in degree of detail with the object of showing the uniformity and continuity of natural processes. There is a want of some more definite coordinating idea, such as would be supplied by considering the progressive evolution of the world and its processes from the condition of a raw planet up to its completion as the home of man. H. R. M.

Admiral Sir William Robert Mends, G.C.B. By Bowen Stilon Mends. Pp. xvi + 380. (London: John Murray, Albemarle Street, 1899.)

THIS biography is of special interest, as the life of Admiral Sir William Mends was exceptionally active and eventful. The facts are taken chiefly from his diary, and from letters to his wife; and his detailed account of the months he spent in the Crimea during the war, gives a good idea of the difficulties which had to be contended with at the time. The author was evidently keenly alive to the scientific side of his profession, for he states that, so far back as 1830, the young midshipmen on board the *Thetis* had to make daily reckonings of the latitude by star altitudes, and of the longitude by lunar observations. The admirable descriptions which he gives of the ships, afford us an excellent opportunity of noting the advance which has been made in the navy, and the new scientific applications which have been continuously introduced.

The Great Salt Lake Trail. By Colonel H. Inman and Colonel W. F. Cody. Pp. xiii + 529. (New York: The Macmillan Company, 1898.)

THIS book is of great interest, but of little or no scientific importance. It is a valuable contribution to the history of early travel in North America, and comprises stories related by members of the first exploring and trapping expeditions. The remarkable adventures of "Buffalo Bill," one of the authors, are also described.

We feel, on finishing the book, that we have obtained a great deal of information, and a good insight into the gradual and steady growth of civilisation in the part of the United States with which it deals.

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.*]

The Interferometer.

As I have been away from home, I have only to-day seen Lord Rayleigh's letter on the interferometer, in your issue of April 6, and I write at once to state that I agree heartily with all he says. I am quite confident that the "structure" discovered by Prof. Michelson in the spectral lines is a real one existing in the light emitted by the source, and I hold this opinion after a careful study of Prof. Michelson's work, combined with the fact that all the "structure" revealed by the interferometer in the light emitted by a source placed in a strong magnetic field is in general accord with my own observations with a 21·5 feet grating.

The law deduced by Prof. Michelson, from his observations with the interferometer, for the *amount* of the magnetic (Zeeman) effect, viz. that "it is approximately the same for all colours and all substances," was, however, at such utter variance with all observations made with a good grating, that I felt bound to question the general performance of an instrument which yielded such a law. My opposition was directed against this law, and if the interferometer had insisted on it, then the interferometer must be discarded as a measuring instrument, or be standardised according to some other scheme.

I am very glad, however, to hear from Prof. Michelson that the law announced by him was probably generalised from insufficient data, and that the interferometer is not at fault. This being conceded, and the law being abandoned, I am thoroughly satisfied, and my confidence in the instrument is re-established.

I may just add that the question as to whether the working of the instrument is prejudiced by "diffraction" or not, was not raised by me, but by others; nor did I intend for a moment to support the idea that the phenomena were due to diffraction. The main phenomena revealed are certainly not due to diffraction, and it is not easy to see where diffraction can come in. The light, of course, passes through a slit, and through other pieces of optical apparatus; and I thought it just possible that some of the minor effects—some of the little "humps," perhaps, in Prof. Michelson's drawings—might be due to transmission through the slit or other pieces of apparatus. It is very easy to determine, however, if diffraction plays any part, for the effects due to it should be similar for all wave-lengths, and should therefore attend all spectral lines varying merely in scale for the different wave-lengths. It is hardly necessary, however, to mention this obvious fact, and I am sure it has been duly taken into account long ago by Prof. Michelson.

THOMAS PRESTON.

Bardowie, Orwell Park, Dublin, April 21.

Absolute Determination of the Ohm.

THE recent great advances in methods of calculating coefficients of mutual and self-induction, due to Prof. Jones and his colleagues in the work, has suggested that a method, which occurred to me some years ago, for the absolute determination of resistance might now be employed with, I think, some advantages over even the Lorentz method. It is as follows:—Take an earth inductor coil, fixed so that it can revolve continuously, thus giving a pure sine voltage, due to cutting the lines of the earth's magnetic field. Take the coils made by the Committee for the determination of the ampere, as described by Prof. Ayrton, and use the two outside coils as the primary and the inside coil as the secondary of a transformer. Pass the current from the earth inductor through one set of coils of a Kelvin balance, and thence through the primary of the transformer. Then through the (non-inductive or easily calculated inductive) resistance required to be measured, thence back to the earth inductor. Connect the secondary of the transformer to the other set of coils of the Kelvin balance, and speed up the earth inductor till the Kelvin balance arm becomes horizontal, and the pull on the two sets of coils is equal. Then take out the resistance we are measuring, and speed up the inductor till the Kelvin balance comes to zero again.

This, with the angular velocity of the earth inductor, is all we need for determining the absolute measure of the resistance, since we know by calculation the coefficient of mutual induction between the primary and secondary of the transformer.

The method has some advantages. The value of the earth's field need not be constant. Thermo-currents make no difference, as we are using A.C. voltages, and these may be taken very large compared with any possible thermo-effect in the primary. The same coils would be used for determining both the ohm and ampere, so that any error in calculating the coefficients for them would affect both units. Modifications will readily suggest themselves; as, for instance, two sets of such coils, one on each arm of a balance, and the movable coils acting both as secondary and as the movable coil of a Kelvin balance.

REGINALD A. FESSENDEN.

Western University of Pennsylvania, April 3.

Fourier's Series.

I SHOULD like to correct a careless error which I made (NATURE, December 29, 1898) in describing the limiting form of the family of curves represented by the equation

$$y = 2(\sin x - \tfrac{1}{2}\sin 2x \ . \ . \ . \ \pm \frac{1}{n}\sin nx) \ . \ . \ . \quad (1)$$

as a zigzag line consisting of alternate inclined and vertical portions. The inclined portions were correctly given, but the vertical portions, which are bisected by the axis of X, extend beyond the points where they meet the inclined portions, their total lengths being expressed by four times the definite integral

$$\int_0^\pi \frac{\sin u}{u} du.$$

If we call this combination of inclined and vertical lines C, and the graph of equation (1) C_n, and if any finite distance d be specified, and we take for n any number greater than $100/d^2$, the distance of every point in C_n from C is less than d, and the distance of every point in C from C_n is also less than d. We may therefore call C the limit (or limiting form) of the sequence of curves of which C_n is the general designation.

But this limiting form of the graphs of the functions expressed by the sum (1) is different from the graph of the function expressed by the limit of that sum. In the latter the vertical portions are wanting, except their middle points.

I think this distinction important; for (with exception of what relates to my unfortunate blunder described above), whatever differences of opinion have been expressed on this subject seem due, for the most part, to the fact that some writers have had in mind the *limit of the graphs*, and others the *graph of the limit* of the sum. A misunderstanding on this point is a natural consequence of the usage which allows us to omit the word *limit* in certain connections, as when we speak of the sum of an infinite series. In terms thus abbreviated, either of the things which I have sought to distinguish may be called the graph of the sum of the infinite series.

J. WILLARD GIBBS.

New Haven, April 12.

Tasmanian Firesticks.

WHILE preparing for a second edition of the "Aborigines of Tasmania, I received from Mr. Jas. Backhouse Walker, of Hobart, two separate accounts of fire-making by the aborigines, which differ materially from those already known. The accounts come from two very old colonists, Mr. Rayner and Mr. Cotton, and describe fire as being obtained by means of the stick and groove process. Mr. Rayner's account runs thus: "A piece of flat wood was obtained, and a groove was made the full length in the centre. Another piece of wood about a foot in length, with a point like a blunt chisel, was worked with nearly lightning rapidity up and down the groove till it caught in a flame. As soon as the stick caught in a blaze, a piece of burnt fungus, or *punk*, as it is generally termed, was applied, which would keep alight. I cannot say what kind of wood it was. My father has seen them light it. The piece with the groove, he said, was hard, the other soft. The blacks in Australia get fire by the same method. I have seen that done. I think it almost impossible for a white man to do it, for I have seen it tried, and always prove a failure." Cotton's account agrees in the main with Rayner's. We are thus in possession of accounts of three distinct methods of fire production, viz.: (1) flint and tinder; (2) fire drill and socket; (3) stick and groove. At first sight it may appear incredible that a race so low in culture could have known and used these methods; nevertheless such a supposition might occur, for some neighbouring tribes in Australia are known to have at least two methods. As regards the Tasmanians, we may, I think, leave out of consideration the flint process, as both Furneaux and La Billardière seem to have mistaken so-called flint implements for fire flints. We may also eliminate indefinite accounts which simply refer to the process used as one of rubbing two sticks together, although rubbing describes rather the stick and groove method than the drill process. We may also omit the statement about the fire-drill supplied by Bomirck's bushranger as being untrustworthy. We are thus left with the two specimens of fire-drill (in the Pitt-Rivers Museum, Oxford, and in the possession of Sir John Lubbock, respectively) supplied by Dr. Milligan and Protector Robinson, with Melville's description and with A. H. Davies' description. When Melville published his V. D. Almanac in 1833, he gave a short account of the aborigines, but to fire-making he made no reference at all; when he wrote his "Present State of Australia" (mostly an account of Tasmania), printed in London in 1850, he described the drill method of making fire as having been used by the Tasmanians. But, in the meanwhile, Davies, writing in 1845 in the *Tasm. Journ. of Sci.*, says he is "informed" that the Tasmanians raised fire by the drill process. But this statement, on hearsay, was made long after the aborigines had been deported to Flinders Island (1837), and after they had long been familiar with Australian aborigines imported into Tasmania; so that, although his statements may in general be relied on, this one wants confirmatory support, especially as his statement is the first one describing the drill process as being a Tasmanian method. Melville's account appears to me to be taken from Davies. Milligan knew nothing of the aborigines until 1847, when he was put in charge of them at Oyster Cove after their return from Flinders Island, and at a time when it was not likely that, in close proximity to European settlements, they would have continued to produce fire by native methods. Although we are much indebted to Milligan for the vocabularies, on the other hand there is considerable carelessness in his translation of the native sentences, and it is well known locally he was not interested in his charge. Hence his presentation to Barnard Davies of a fire drill as a Tasmanian instrument does not prove the drill to have been Tasmanian. Robinson, in spite of his intimate intercourse with the aborigines, and his voluminous reports on his doings while capturing the wretched remnants, has left us such a comparatively small amount of information concerning them, that I have for a long time past come to the conclusion that he was a very unobservant man, an opinion largely confirmed by his presentation to Barnard Davies of ground Australian stone implements as Tasmanian, but the real origin of which was settled as Australian by Prof. Tylor's paper on the subject read at the Oxford meeting of the British Association. As Robinson was afterwards Protector of Aborigines in Victoria, it is not at all unlikely that he confused his specimens, and called them Tasmanian instead of Australian. On the other hand, we have circumstantial accounts of stick and groove fire-making apparatus by two settlers, well advanced in years, who carry us back to the early part of the century when the natives were still roaming about the country before they were wholly robbed of it, and to a time when they had been little in touch with Australians or Europeans. Either there were two methods of fire-production used by the natives, or the stick and groove was the only one.

H. LING ROTH.

Halifax, England, April 13.

WIRELESS TELEGRAPHY.

ALTHOUGH at the present moment there is not a single commercial line of the so-called wireless telegraphy at work, and probably not a single penny has yet been earned by those exploiting it, the one pound shares of the Company have been quoted at six pounds, and perhaps more. At the same time the shares of many of the Submarine Cable Companies have fallen considerably owing to the popular delusion that wireless telegraphy is going to displace wires. Thus a popular scare—the outcome of ignorance—has appreciated the one property and depreciated the other to the value of about

two millions sterling. It reminds one of the influence of electric light on gas undertakings some twenty years ago. Gas stock depreciated then many millions. Now they never were so high in value. There was some excuse then. The electric light was a great boon. It was a dangerous rival. There is no excuse now. Nothing whatever about wireless telegraphy has given the smallest indication that it is going to supplant wires. It simply fills a want. Communications between lightships and shore, between ship and ship, between moving ships and shore, between isolated lighthouses and the mainland, become possible. They were not so before.

Messages between the South Foreland and Boulogne have been sent. There is no reason why they should not. Mr. Preece, many years ago, indicated how it could be done. Mr. Marconi has done it in another way. But an isolated experiment, however successful, and a single circuit, though it transmitted messages accurately at the rate of twenty words a minute, is not going to replace one of the present submarine wires, each of which can transmit similar messages at 600 words a minute. Wireless telegraphy may maintain communication with outlying islands when cables break down. It did so by the Post Office with the island of Mull in 1895, before Mr. Marconi was heard of; but it is not going to replace one single cable between Great Britain and the continent. Marconi's system has now been before the public for nearly two years, but we have not heard of anything new from a scientific point of view since it was first published. The last report is that it is possible to direct the signals to one selected point. Two years ago it was said to be able to do the same thing by tuning. The fact is that we have in these repeated sensational experiments a pure scientific apparatus boomed by energetic financial speculators for their own individual gain, and not for the benefit of the public —the worst feature of this money-grubbing age.

THE MICHELSON ECHELON SPECTROSCOPE.

SINCE Prof. Michelson's announcement of his new form of spectroscope, in the *American Journal of Science*, March 1898, and *Astro-Physical Journal*, vol. viii. p. 37, 1898, all having any connection with spectroscopic work have been waiting with great interest to see the performance of the instrument. This curiosity has now been satisfied in a most complete manner, an echelon of fairly large dimensions having been successfully constructed by Mr. A. Hilger, of Islington, which the writer has had the pleasure of examining. Before describing this, it may be useful, for the benefit of many who have not noticed the previous reports, to briefly state the characteristics of the new spectroscope.

In an ordinary diffraction grating, consisting of equidistant lines ruled on a plate of glass or speculum metal, the resolving power is determined by the product $(m\,n)$ of the total number of lines (n) and the order of spectrum observed (m). As in this type of grating the succeeding orders after the first decrease in brightness very rapidly, little progress has been made in the endeavour to increase the order observed. Many attempts have, indeed, been made to concentrate the light in one of the first three orders by means of special adjustment of the ruling, so that higher magnifications could be used, but with little or no certainty or equality of result. If, however, instead of obtaining the phase difference by alternations of opaque and transparent spaces, the necessary retardation is brought about by a progressive damping, as it were, of the wave-front by increasing thicknesses of an absorbing transparent material, it would seem that it is possible to throw practically the whole of the transmitted light into any *one* order. In such a case the grating space must be proportionately increased so that it remains commensurate with the degree of the order; and as the lines would need to be made with no more accuracy than before, the grating could be completed in less time, and therefore with less chance of deformity due to temperature and other changes.

Instead, however, of attempting to rule lines on glass or metal, which would be an extremely difficult matter for this purpose, Prof. Michelson took an entirely original step by building up the spaces with a number of strips of glass having optically plane surfaces. The appearance presented by such a dispersive arrangement will then be as shown in the following diagram (Fig. 1), the arrows indicating the directions of the incident and transmitted rays.

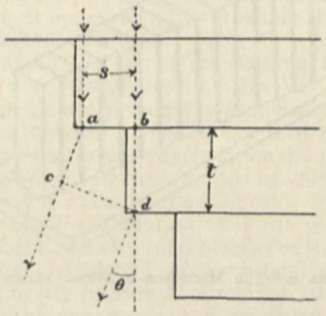


FIG. 1.—Showing paths of direct and diffracted rays through the echelon.

"The interesting feature of the new arrangement is the smallness of the number of elements necessary to give results which may be comparable to those given by the best ordinary gratings. This can be simply shown as follows: Let $ab = s$, and $bd = t$ be the surfaces of one of the steps between two of the parallel plates of the echelon. If then m is the order of spectrum to be observed, we shall have

$$m\lambda = \mu \,.\, bd - ac,$$

or

$$m\lambda = \mu.t - t\cos\theta + s\sin\theta.$$

Therefore

$$\frac{d\theta}{d\lambda} = \frac{m - t\,.\,\frac{d\mu}{d\lambda}}{t\sin\theta + s\cos\theta}$$

and

$$\frac{d\theta_1}{dm} = \frac{\lambda}{t\sin\theta + s\cos\theta};$$

If $\delta\theta$ is the displacement corresponding to $\delta\lambda$, and $\delta\theta_1$ is that corresponding to $\delta m = 1$, then assuming Cauchy's formula,

$$\mu = a + \frac{b}{\lambda^2},$$

and taking as a first approximation

$$m = (\mu - 1)\frac{t}{\lambda},$$

we have

$$\frac{\delta\theta}{\delta\theta_1} = \left[(\mu - 1) + 2(\mu - a)\right]\frac{t}{\lambda}\,.\,\frac{\delta\lambda}{\lambda}.$$

"For most specimens of flint glass the coefficient of $\frac{t}{\lambda}$ in the last expression is approximately equal to unity, so that if $\frac{\delta\lambda}{\lambda} = \cdot001$, say, as in the case of the two yellow sodium lines, and $t = 5$ mm. $= 10{,}000\ \lambda$, then

$$d\theta = 10\,d\theta_1;$$

that is, the two sodium lines would be seen separated by ten times the distance between the successive spectra.

The resolving power of this combination is mn, just as in the case of ordinary gratings; and thus, with a battery of *twenty* elements, each 5 mm. thick (corresponding to $m=5000$), the resolving power would theoretically be 100,000, which is as high as that of the best gratings available at present."

Although, as stated above, the resolving power is independent of the *number* of plates, being determined by the total thickness, yet for any given purpose the number of elements has to be considered. This is evident when it is remembered how closely the successive spectra follow each other. With a small number of plates the

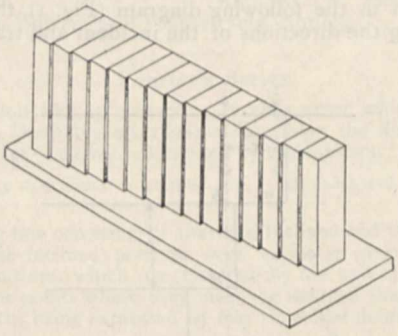


FIG. 2.—The Michelson Echelon. (Scale ½.)

overlapping may be so inconvenient as to render the lines unrecognisable, so that, in designing an echelon, this has to be taken into account. If the spectrum to be examined consists of a few sharp lines, the overlapping may be considerable before it causes confusion, and a *few thick* plates will suffice. If, however, the investigation of doubling or widening of special lines in ordinary spectra is needed, then the echelon could advantageously be constructed of a larger number of elements of less thickness to give the necessary resolution.

The echelon made by Mr. Hilger consists of fifteen plates, each 7·5 mm. in thickness and 45 mm. high, the width (S) of each step being 1 mm., and the order of spectrum observed being therefore about the 8000th. Its appearance is shown in the annexed cut (Fig. 2), the cell in which it is usually held having been removed. In use the echelon is laid horizontally on the table of an ordinary spectrometer provided with collimator and telescope, and, as the line of vision is almost direct, it can be placed at once approximately into position. If, however, the slit of the collimator be illuminated with either white light or any source consisting of many radiations, the overlapping of the successive spectra will simply give an almost white band across the field. To obviate this, it is necessary to only illuminate the slit with light which is sensibly monochromatic. In the case of sodium or mercury vapour there need be nothing more than the source itself, as the light is sufficiently simple in their case, but in general some light-filter will have to be used. This may be done by first passing the light through an auxiliary spectroscope, and focussing the spectrum given by it on the slit of the echelon spectrometer, thus isolating a small region which will be approximately monochromatic. This arrangement is illustrated in Fig. 3, which shows how the echelon (E) is fitted up in actual work. The form of apparatus for obtaining monochromatic light will depend on the resources of the observer. Obviously a direct vision prism will be most convenient, as then the source of light can be kept stationary while the spectrum is caused to traverse the slit in order to transmit the different lines. If only an ordinary spectroscope with deviating prism is available, then the light source must be secured to the collimator and moved round with it. There is a very simple method, however, of converting an ordinary prism into a direct-vision one, viz. by fixing a plane mirror to the back of the prism. The arrangement is described by Dr. Fuchs in *Zeitschr. für Instr Kunde*, vol. i. p. 352 (1881), and has later been developed by Wadsworth ("Astronomy and Astro-Physics," vol. xiii. p. 844). In this case, all that is necessary is to revolve the prism-mirror combination about the centre of the back of the prism, the axial emergent ray being always at minimum deviation. This combination is shown in Fig. 3, P being the prism-mirror system between a collimator and telescope; the collimator (C) of the echelon (E) being then directed axially with the telescope of the auxiliary instrument. The observing telescope (T) will be almost directly axial with the collimator, as the deviation seldom amounts to more than half a degree for the line under examination.

With the above echelon the "D" lines of sodium are separated by about sixteen minutes of arc, this being about ten times the dispersion of an ordinary good spectroscope. The successive spectra are only separated by about two minutes of arc, so that generally two orders of spectra are visible in the field together; in practice the echelon can be slightly inclined, thus reducing the intensity of one of these almost to zero, so that measurements can be made on the remaining one with less risk of confusion.

One is surprised at the first experience with the instrument by the brightness of the spectra, considering the enormous dispersion and the path traversed by the light. This is no doubt partly due to the incidence on the plates being very nearly normal, thus diminishing the losses by reflection.

In making the plates it was a very delicate matter to obtain all of exactly the same thickness. This was

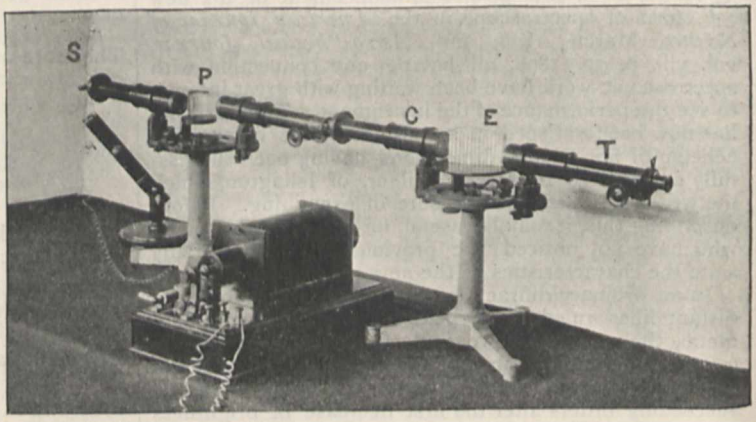


FIG. 3.—The echelon in use.

done by first producing a large plane-parallel plate, and then cutting out the required pieces from it. In the making of this plate the ordinary tests for plane parallelism were found quite inadequate, and every part of it was tested by viewing the interference bands produced between the two surfaces while illuminated by a parallel beam of monochromatic light. Each elementary section of the surface was then refigured until the interference patterns were similar throughout. This will give some idea of the patience and skill required to produce a successful result.

From the fact of its being necessary to use monochromatic light, and also from the limited range owing to the short distance between the spectra, it would appear that the use of the new spectroscope will of necessity be somewhat confined to special branches of research. For the investigation of the Zeeman effect, and the resolution of hitherto undivided multiple lines, it should prove of great service, the relatively bright spectrum obtained rendering it possible to examine the fainter lines which have perforce been neglected up to the present.

Naturally, the first essay in constructing such an entirely new piece of optical work was fraught with many difficulties ; but, encouraged by his success, Mr. Hilger expresses himself as quite prepared to undertake the building up of echelons of much higher power than the one he has just completed. CHARLES P. BUTLER.

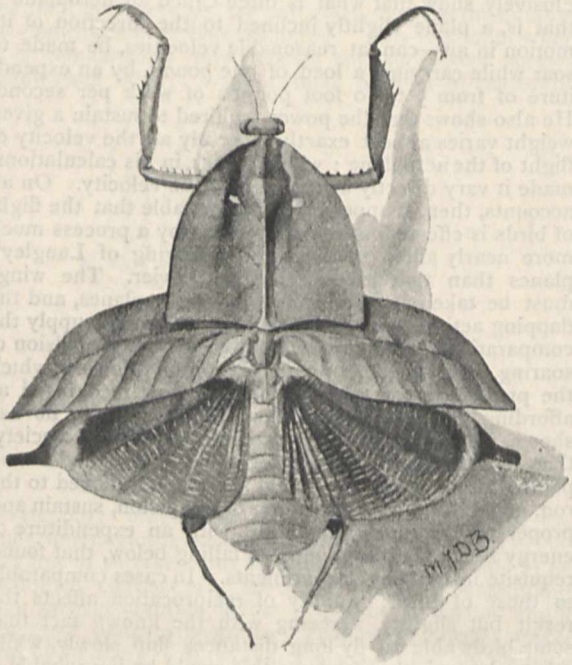
FLIGHT OF BIRDS.

"THE way of a bird in the air" has been for ages a perplexing one ; and, until recently, its mechanical explanation has been too much left to persons whom the more sober members of the body scientific were apt to class as "cranks," to use an Americanism. If confirmation of such judgment were necessary, it was afforded by a report, made to the Institute of France about 1830 by Navier, who was no "crank," member and reporter of a commission of eminent scientific men, in which the subject was discussed. Navier drew a distinction, since generally accepted, between hovering, in which the bird remains stationary in the air, as a hawk or kite "winnowing," on the one hand, and progressive flight, accompanied by flapping of the wings, in which the bird moves forward rapidly, as a carrier pigeon or swallow on a journey, on the other. A third mode of flight, called soaring, has, of late, attracted much attention. It consists in the bird maintaining forward motion, straight or circling, sometimes for minutes together, with very occasional and slight flaps of the wing ; in some cases with none at all. In these three kinds of flight, observations easily made by any one show that soaring appears to require the least exertion, though not many birds can manage it well ; progressive flapping flight is common, and many birds can keep it up for hours ; while only a few can manage hovering, which appears to involve much exertion, and, as the Duke of Argyll expresses it, seems to be the most difficult feat of wingmanship a bird can execute. Navier, however, concluded hovering to be far easier than progressive flight, requiring only about one-twentieth of the exertion of this latter ; soaring he does not appear to have considered. His results, moreover, made very heavy demands on the animal, considered as a machine. According to him, a bird must be able to give out energy at, or exceeding, the rate of 1000 foot pounds per second per pound of its own weight, whereas no ordinary land animal whose work is directly measurable gives out continuously for hours more than about half a foot pound per second per pound of its own weight. This excessively disproportionate activity of birds, in the proportion of over two thousand to one, as compared with other animals, seems sufficient to invalidate the basis of calculation ; but the argument is further strengthened on finding that a carrier pigeon, for instance, does not contain enough combustible matter to maintain its own flight, and live, for anything like an hour, if Navier be right. A thousand foot pounds is rather more than one British thermal unit, so that one heat unit, if wholly converted into useful mechanical power, would carry a pound weight for somewhat less than four-fifths of a second. The bird's feathers and bones must be preserved, and water or blood are not combustibles, so that not more than four ounces in the pound of its weight can be reckoned as available combustible matter. If this be as good fuel as paraffin oil (and some birds are oily), each pound of the bird's body can supply about 5000 heat units, able to carry it for 4000 seconds or thereabouts, or less than an hour and ten minutes. At the end of this time the bird would be a wet feathered skeleton with a few ashes inside, rattling among the bones, perhaps. On the other hand, Langley's experiments, which were very carefully made, and agree in all material points with others of the same nature, conclusively show that what is often called an aëroplane—that is, a plane slightly inclined to the direction of its motion in air—can, at reasonable velocities, be made to soar while carrying a load of one pound, by an expenditure of from 5 to 10 foot pounds of work per second. He also shows that the power required to sustain a given weight varies almost exactly inversely as the velocity of flight of the aëroplane ; while Navier, in his calculations, made it vary directly as the cube of the velocity. On all accounts, then, it appears highly probable that the flight of birds is effected, in ordinary cases, by a process much more nearly allied to that of the soaring of Langley's planes than that investigated by Navier. The wings must be taken to act principally as aëroplanes, and the flapping action be used to enable the bird to supply the comparatively small power required for the propulsion of soaring aëroplanes. In confirmation of this view, which the present writer takes to be that now recognised as affording the best explanation of birds' flight, he has shown, in a paper recently read before the Royal Society, that a machine consisting of a vertical cylinder and piston, with a nearly horizontal aëroplane attached to the rod, could, by the reciprocation of the piston, sustain and propel itself in horizontal flight, with an expenditure of energy little exceeding, perhaps falling below, that found requisite in Langley's experiments. In cases comparable to those of birds, rapidity of reciprocation affects the result but slightly, agreeing with the known fact that some birds able to fly long distances flap slowly, while others flap quickly ; whereas this would be improbable if any considerable intrinsic difference in economy of labour existed between slow and quick flapping. As to hovering, the conditions are too far removed from those of experiments on soaring to allow reliance to be placed on numerical results ; there does not appear any absolute necessity for a higher rate of energy-expenditure than in ordinary flight, but the conditions of economical working, particularly as to a sufficiently quick flapping, seem to be more difficult of attainment. In prolonged soaring flight it appears likely, from theoretical investigations by Lord Kelvin, as well as consistent with observation, that local air currents may be largely concerned, as a skilful bird might, by gliding in and out among currents having different velocities, appropriate for his own use and support enough of the extra energy of the quicker currents, to keep himself going continuously, without any exertion, beyond that involved in steering, on his own part.

With respect to the very interesting, though probably not very practical, question of man's mechanical flight, Langley's and Maxim's experiments show it to be at least within the range of possibility ; but, if the conclusions of the paper above alluded to be correct, the most economical method of effecting it would involve using the supporting aëroplanes as birds use wings—that is, as propellers and aëroplanes combined in one. Purely constructive difficulties interfere seriously with designs for movable wings of any considerable size, especially if their motion is a reciprocating one, while there is another whole tribe of difficulties connected with the balancing and steering, very possibly greater than those which beset the beginner on a bicycle ; so that, on the whole, we can scarcely feel as if we were within any very measurable distance of emulating the feats of Dædalus, without almost certainly suffering the fate of his less fortunate son. MAURICE F. FITZGERALD.

A POPULAR WORK ON INSECTS.[1]

THIS is a popular book on somewhat new lines, being entirely devoted to *Orthoptera* and *Lepidoptera*. It is well written, and up to date; and has the merit of dealing mainly with branches of the subject which are not hackneyed. The illustrations are new and well selected, and chiefly represent species which have not been figured



A remarkable Mantis from Borneo.

in any easily accessible work. These were all executed for the author by her sister; and the life-size figures are very good. It has been necessary to reduce the dimensions of some of the insects figured; which is a pity, for though this is sometimes necessary in the case of a book of limited size, it always seems to us to spoil the effect of even a good figure. In the *Orthoptera* the families dealt with are *Phasmidae*, *Mantidae*, *Acridiidae* and *Locustidae*. The habits, transformations, and senses of these insects are discussed generally, limited space necessarily precluding many references to individual species. Several very curious insects are figured, including *Deroplatys truncata*, a remarkable Mantis from Borneo, which is represented at p. 32, and also on the cover. When the book is held straight up, the latter figure has been fancifully compared to a ballet dancer; but this odd resemblance is less obvious in the figure in the text, owing to the shading.

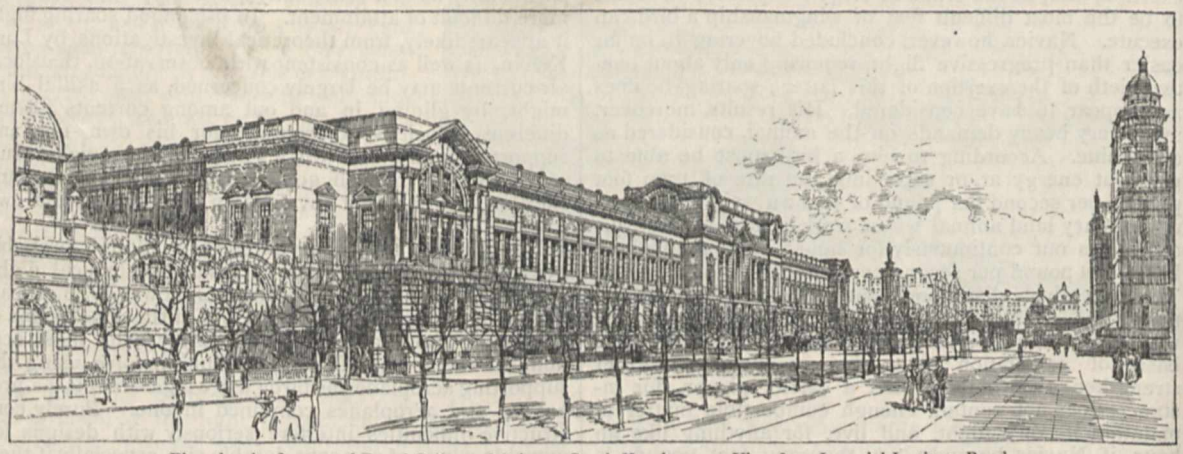
The chapters on *Lepidoptera*, some of which do not now appear for the first time, commence with "Symbols of Psyche," including a sketch of the story of Cupid and Psyche from Apuleius, prefatory to general observations on butterflies. The other chapters relate to "Day-flying Moths" (*Castniidae*, *Uraniidae*, &c.); "The Case Moths" (*Psychidae*); "The Hawk Moths" (*Sphingidae*); and "The Death's Head Moth."

The book will be read with interest both by entomologists and by any others who are interested in natural history; and it is not unlikely that many may acquire information from it, which was previously unknown to them. The book appears to have been very carefully composed, and we have not noticed any very serious errors. In one place, however, the name of the American entomologist, Bruner, is spelt Brunner, probably by confusion with the Austrian entomologist, Brunner von Wattenwyl; and in the notice of the colours of the *Mantidae*, the curious genus *Metallyticus*, which similates those brilliantly coloured beetles, the *Buprestidae*, might perhaps have been mentioned. But there is little to find fault with in so commendable a piece of work as the book before us. W. F. K.

[1] "True Tales of the Insects." By L. N. Badenoch, author of "Romance of the Insect World." With forty-four illustrations by Margaret J. D. Badenoch. Pp. xviii + 255. (London: Chapman and Hall, Ltd.)

THE SCIENCE BUILDINGS AT SOUTH KENSINGTON.

WE are glad that the Government has conceded to the wish of men of science, and decided to place the new science buildings at South Kensington on the west side of Exhibition Road, between the Natural History Museum and Imperial Institute Road. It will be remembered that a year ago it was proposed to build the new laboratories for the Royal College of Science on the restricted site available on the east side of Exhibition Road, notwithstanding the fact that the large plot on the west side had been obtained by the Government from the 1851 Exhibition Commissioners for a nominal sum on the understanding that it was to be used for the erection of science buildings. The proposal was condemned by both science and art; and memorials protesting against it were signed by eminent Fellows of the Royal Society, and by the leading representatives of art. These memorials,



First sketch of proposed Royal College of Science, South Kensington. View from Imperial Institute Road.

in which the facts of the case were clearly set forth, were printed in the last volume of NATURE, which also contains several articles bearing upon the question then at issue (vol. lviii. pp. 54, 155, 176, 294). It is satisfactory to know that the Government has been guided by the unmistakable expression of opinion which their proposal elicited, and has arranged for the erection of the new science buildings on the land obtained for that purpose on the west side of Exhibition Road. By the kindness of Mr. Aston Webb, we are able to give a copy of his first sketch of the building which it is proposed to erect facing the Imperial Institute in Imperial Institute Road. It will be seen that the building will provide science with a worthy home, in which instruction and investigation can be carried on under good conditions. We hope in a future issue to give detailed plans of the chemical and physical laboratories. The position of the astro-physical laboratory has not yet been decided, but particulars will be given as soon as they are available.

NOTES.

IT has been decided to give the name "Victoria and Albert Museum" to the new building at South Kensington, the foundation stone of which will be laid by the Queen on May 17.

THE Council of the Institution of Civil Engineers have made the following awards for papers read and discussed before the Institution during the past Session:—A George Stephenson Medal and Premium to Mr. R. A. Hadfield; a Telford Medal and Premium to Mr. J. T. Milton; Watt Medals and Premiums to Sir Albert J. Durston, K.C.B., and Mr. H. J. Oram; a Crampton Prize to Mr. Francis Fox; a Manby Premium to Sir William Roberts-Austen, K.C.B.; Telford Premiums to Messrs. J. M. Dobson, W. G. Kirkaldy, and A. P. Head. The presentation of these awards, together with those for papers which have not been subject to discussion, and will be announced later, will take place at the inaugural meeting of next Session.

THE American National Academy of Sciences has awarded the fifth Watson medal to Dr. David Gill, F.R.S., Astronomer Royal at the Cape.

THE Council of the Royal College of Surgeons of England have resolved that the centenary of the foundation of the College shall be celebrated on a suitable date between March 22 and June 30, 1900.

WE regret to see the announcement of the death, at Paris, of the distinguished chemist, Prof. M. Charles Friedel, member of the Paris Academy of Sciences.

MR. ROLLO APPLEYARD, the official reporter of the Physical Society of London, has had to resign his office owing to the pressure of other work.

THE Sydney correspondent of the *Times* states that to-morrow (April 28) Sir Frederick Darley, the Lieutenant-Governor, will dedicate for public use the site of Captain Cook's landing on Kurnell Beach, in Botany Bay, on April 28, 1770.

AN excursion to Brittany has been arranged by the Geologists' Association for the Whitsuntide holidays, May 17-24, the directors being Dr. Charles Barrois and M. P. Lebesconte. The places to be visited by the members include several of special geological interest.

THE autumn Congress of the Sanitary Institute will be opened at Southampton on August 29. The preliminary circular announces that the president of Section I. (Sanitary Science and Preventive Medicine) will be Sir Joseph Ewart; of Section II. (Engineering and Architecture), Mr. James Lemon; and of Section III. (Physics, Chemistry, and Biology), Prof. Percy J. Frankland, F.R.S.

IT is announced that the Committee to which was entrusted the duty of deciding upon a suitable memorial to be erected by the citizens of Philadelphia, in honour of the late Dr. Pepper, in recognition of his many services to the community, has recommended the erection, at a cost of 10,000 dollars (2000*l.*), of a statue, which it is proposed shall be placed upon the Plaza of City Hall.

THE Danish Meteorological Institute has issued a Circular proposing that all the Meteorological Institutes of Europe and America shall subscribe to the cost of daily telegraphic weather reports from Iceland and the Faroes. The Great Northern Telegraph Company has undertaken, as soon as fourteen Institutes have notified their adhesion to the proposal, to lay a telegraph cable to the Islands. The cost of the daily reports is to be partly determined by the size of the various countries subscribing for them.

UNDER the direction of the Government of Belgium, Prof. G. Gilson, Louvain University, is about to commence a series of experiments on the currents of the North Sea. On Saturday, April 29, the first set of bottles will be set off from the West Hindar light vessel, 2° 26′ E. longitude, 51° 23′ N. latitude—*i.e.* about twenty miles north-west of Ostend. Each bottle contains a printed card, and it is hoped that any one who picks up one of these bottles will take out the card and fill up the blanks reserved for the place and date of finding, name and place if found on the shore, latitude and longitude if on the sea, or bearings, if any. Finders are not required to pay postage.

THE *Morning Post* states that a Committee of the St. Petersburg Astronomical Society, appointed to examine the question of the reform of the Russian Calendar, having applied to all the Government Departments for their opinions on the question, the Ministries of Communications, the Interior, Finance, and Foreign Affairs have replied in favour of the adoption of the proposed reform at an early date. The Committee will proceed with its labours immediately, and will probably have concluded them by the beginning of June.

A PRIZE, founded by Baron Léon de Lenval of Nice, will be awarded at the International Otological Congress to be held in London from August 8 to 11. The prize is a sum of 3000 francs, bearing the name of "The Lenval Prize," and it will be awarded to the author of the most marked advances in the practical treatment of affections of hearing since the last Congress, or to the inventor of any new apparatus which is readily portable and improves considerably the hearing-power of deaf persons. All persons desirous of competing for the prize are requested to communicate with Mr. Cresswell Baber, honorary secretary general, 46 Brunswick Square, Brighton, stating the facts on which their claim is based.

WE learn from the *Lancet* that a Congress, having for its subject the prevention of tuberculosis, will be held in Berlin, under the patronage of H.I.M. the Empress of Germany, from May 24 to May 27. The president is the Imperial Chancellor, Count Hohenlohe-Schillingsfürst, and the vice-president is Dr. von Leyden. The objects of the conference are to make the dangers of tuberculosis as a disease known among people in general, and the best means for combating the disease. Besides these subjects will be discussed the present range of knowledge concerning tuberculosis and the various methods of prevention, more especially the treatment of sanatoria.

A WARD of the Royal Southern Hospital, Liverpool, to be used in connection with the new school for the treatment of tropical diseases, was opened by Lord Lister on Saturday. The *Lancet* states that Major Ronald Ross, who has just been elected to the post of lecturer in tropical medicine in the school, has

had eighteen years' training in his subject, while his discoveries in relation to the malarial parasite have placed him amongst the foremost investigators. In January last Dr. Laveran communicated Major Ross's researches to the French Academy of Medicine, the Italian observers have confirmed his observations, and more recently Prof. Koch has shown their importance and accuracy. In no place in this country will such work be more generally appreciated than in Liverpool.

PROF. HEINRICH KIEPERT, the distinguished geographer, died at Berlin on Friday last, at the age of eighty-one. His geographical work consisted largely in the construction of maps illustrative of ancient history, and more especially of South-Eastern Europe and Western Asia. Prof. Kiepert was born at Berlin, and studied at the University of that city. After having charge for a few years of the Geographical Institute in Weimar, Kiepert returned to Berlin, and in 1859 was appointed Extraordinary Professor, and in 1874 Ordinary Professor, of Geography in the University. His activity in the production of maps and atlases, together with memoirs to accompany these, continued almost unabated to the end.

THE death is announced, at eighty-two years of age, of Mr. Jabez Hogg, distinguished as an ophthalmic surgeon, microscopist, and writer of scientific works. He was vice-president of the Medical Society in 1851–52, was elected a Fellow of the Linnean Society in 1866, and honorary secretary to the Royal Microscopical Society from 1867 to 1872. He was the first president of the Medical Microscopical Society. Mr. Hogg was a prolific writer, and was the author of works on photography, domestic medicine, English forests and forest trees, experimental and natural philosophy; history, construction, and applications of the microscope; colour blindness, microscopic examination of water, and numerous papers on disease of the eye, contributed to the medical journals.

MR. JOSEPH WOLF, an artist whose pictures of animals have delighted many naturalists, died on Thursday last, at the age of seventy-nine. Referring to his career, the *Times* states that he was early apprenticed to a lithographer, studied in Antwerp, and came by invitation to London to take up the work of illustration for Gray's "Genera of Birds," a standard work then in progress. This led to work for the *Proceedings* of the Zoological and Linnean Societies. Among other books for which he made drawings were "The Birds of North-East Africa," "The Birds of Japan," and Gould's "Birds of Great Britain"; while he also helped to illustrate Livingstone's "Missionary Travels," Wallace's "Malay Archipelago," and Baldwin's "African Hunting." His studio was once a resort of explorers, artists, and scientific men; among his friends and admirers were Darwin, Owen, Oswell, and the Duke of Argyll. It is, however, chiefly by the books he has enriched with inimitable illustrations that he is best known. In the seventies his "Life and Habits of Wild Animals" was in the hands of every naturalist.

REUTER'S Agency is informed that the following are Dr. Sven Hedin's plans for his new expedition in Central Asia:—Dr. Sven Hedin will start from Stockholm at the end of June, and will travel direct through Russia and Turkestan to Kashgar, taking a new route over the mountains. On reaching Kashgar he will proceed in an easterly direction for the purpose of making fresh investigations in Chinese Turkestan, where he hopes to find further antiquities. Thence he will visit the Lop-nor region, and will cross the great Sand Desert by more than one route. After going to Tibet and exploring that portion of the country to the south of his former route, he will return *via* India. As in the case of his famous journey across Asia, Dr. Sven Hedin's objects on this expedition are purely scientific. Dr. Hedin is, however, better prepared than he was on that occasion, and hopes to achieve even better results than he did then. The expenses of the expedition, which will amount to 2000*l.*, have been defrayed by King Oscar, Mr. Emanuel Nobel, and others.

THE first annual report of the Secretary of the Washington Academy of Sciences has been issued. For several years efforts have been made to federate the various scientific societies in Washington, and a committee appointed with this end in view formulated a plan of co-operation in 1882, which was adopted by the Anthropological and Biological Societies, but was rejected by the Philosophical, and thus failed to be realised. Six years later a movement to secure a permanent committee to deal with questions of common interest was more successful, and a Joint Commission, upon which the several scientific societies were represented, was created. Out of this Commission, which was primarily organised for business purposes, the Washington Academy has grown. The Academy was incorporated a year ago, with Prof. J. R. Eastman as president, Prof. G. K. Gilbert as secretary, and Mr. B. R. Green as treasurer. The vice-presidents, elected on the nomination of the several scientific societies, are: for the Anthropological Society, Prof. J. W. Powell; Biological, Dr. L. O. Howard; Chemical, Mr. H. N. Stokes; Entomological, Mr. W. H. Ashmead; Geographic, Mr. A. Graham Bell; Geological, Mr. C. D. Walcott; and Philosophical, Prof. F. H. Bigelow. In addition to the seven societies here mentioned, the affiliated societies are the Columbia Historical Society, and the Medical Society.

ON Tuesday next, May 2, Prof. Silvanus P. Thompson, F.R.S., will deliver the first of a course of two lectures at the Royal Institution on electric eddy currents. These are the Tyndall lectures. The Friday evening discourse on May 5 will be delivered by Dr. W. J. Russell, F.R.S.; his subject is "Pictures produced on photographic plates in the dark."

THE expenses connected with the preparation and publication of the second volume of the "Rêcueil des données numériques," just issued by the French Physical Society, have been paid by a friend of science who desires to remain anonymous. The amount paid was 9600 francs, in addition to which M. Gauthier-Villars deducted 734 francs from the account as the contribution of the printer towards this valuable work.

MR. F. J. BENNETT, who joined the Geological Survey of England in 1868, has just resigned his post on the staff. During his long service he has mapped large areas of the Cretaceous, Tertiary, and Drift deposits in the Eastern counties, and in Surrey, Berkshire, and Wiltshire. He retires to West Malling in Kent.

DR. M. E. WADSWORTH has protested against the introduction, by Dr. E. Hussak and Mr. G. T. Prior, of the name "Zirkelite" for a new mineral, on the ground that he (Dr. Wadsworth) had previously used the name for a basaltic glassy lava, which often forms the entire mass of thin dykes, and the exterior parts of larger dykes of diabase and melaphyr.

MR. A. A. JULIEN has discussed (*Journal* of the Franklin Institute, April 1899) the elements of strength in the constitution and structure of building-stones. He remarks that blocks of hewn stone are always seamed and weakened by minute cracks. Rude processes of quarrying, the use of heavy hammers, and blasting, are apt to act injuriously on stone, and to cause an inferiority in hewn as compared with sawn cubes. He draws attention to the minute structure of various rocks; and, after all, concludes that the most satisfactory of all tests, when available, under known conditions and of sufficient

antiquity, is the study of weathered surfaces of ancient stone-buildings and monuments.

THE gold-bearing slates of Nova Scotia have been investigated by Mr. J. Edmund Woodman (*Proc. Boston Soc. Nat. Hist.*, vol. xxviii., March 1899). The rocks extend along the eastern side of the country in a belt which averages twenty-five miles in width, and covers an area of about six thousand square miles. They are highly metamorphosed, and are regarded as probably belonging to the Algonkian system. The rocks are intersected by veins of quartz and calcite containing gold, both free and in the various sulphides, which are abundant. Among the veins much interest attaches to the gold-bearing stratified veins, often called "leads"; and it is observed that, although the veins lie parallel to the planes of stratification, they must have come from below, and have been formed from hot waters which bore various substances in solution. Probably in this complicated region the gold is of varied origin. In some cases it must have been deposited with the sediments, and has since been concentrated by subaërial agencies.

IT is many years since the question of the chemical reactions which occur in the pan amalgamation of silver ores has been raised. Since Hague's experiments his conclusions have been accepted that cuprous chloride is formed by the interaction of common salt, bluestone and metallic iron, and that cuprous chloride is instrumental in reducing sulphide of silver. As the result of a series of experiments, however, Mr. H. F. Collins put forward a new account of the pan process at the last meeting of the Institution of Mining and Metallurgy. According to his view, a "chloride" ore is readily treated in an iron pan without bluestone or metallic copper, the silver compounds being directly reduced by the iron. In the case of sulphide ores, treatment is facilitated by the addition of sulphate of copper, which is rapidly reduced to metallic copper by the iron. The copper, whether amalgamated or not, acts on sulphide of silver, reducing it to metal and enabling it to be taken up by the mercury. On the other hand, cuprous chloride, a still more energetic agent in reducing sulphide of silver, never exists in the pan, and in this way the comparatively bad results obtained in the treatment of sulphide ores in the presence of metallic iron are explained. The use of copper-bottomed vessels in the treatment of sulphide ores has been practised for over a century. In such vessels cuprous chloride is formed in considerable quantities.

THE cosmopolitan character of Cairo is exemplified by an announcement which we have received referring to the Ghizeh Zoological Garden. The information is printed in six languages, namely English, French, German, Italian, Greek, and Arabic. From it we learn that the garden is open every day, Sundays included, that the collection of animals is such as pleases the popular mind, and includes two lionesses formerly belonging to the Khalifa at Omdurman, and that a large variety of plants may be seen. The paths extend altogether to a length of six miles (of which three and a half miles are paved with coloured mosaic), the grottos were erected in the time of Ismail Pasha, and more than twenty bridges cross the ornamental water in the grounds. The garden is evidently a very pleasant and instructive place.

MR. A. HALL, of Highbury, has designed an almanac with the object of eliminating the inconvenience consequent on the various days of the months falling on different week days, owing to the changing number of days in each month. His scheme is to make New Year's Day separate from the rest, calling it January 0, and then divide the remaining 364 days into thirteen months of twenty-eight days each. Following this plan, therefore, any particular day of any month will always fall on the same day of the week, and this would, of course, be convenient for many purposes. The extra month he proposes to denote by the name "Christember." The almanac sent us is printed on this principle, and a useful item included is the table of corresponding dates between the Gregorian, Julian, Jewish and Mohammedan calendars.

A SYSTEM of printing telegraphy, known as "Prof. Rowland's Multiplex," is stated by *Engineering* to have been recently tested between Philadelphia and Jersey City with highly satisfactory results. On this system a message is sent and received in legible and easily read type, transmitted from keyboards similar to those of a typewriter, the characters including simply the ordinary alphabet and numerals. The device on trial was made at the Johns Hopkins University in order to demonstrate what merits it possessed and also its weakness, if any, and it is arranged for eight messages, four in each direction, and duplexed in the usual way. The messages are printed on either a tape or a page, and a speed of sixty words a minute has been obtained in some of the experiments, but the limit of speed or the number of messages was not reached. There is no other multiplex printing system sending from a keyboard and received on a page, and this one is only a part of that invented by Prof. Rowland. It is stated that the whole invention contemplates a relay method, by which any amount of territory may be covered, and comprises a system by which eight people in one city can be in communication with eight others in another place over one wire and with absolute secrecy. Among the advantages claimed for the multiplex system is that of less liability of error, since there is only one person engaged, and he the sender; while, by the Morse system, there is an opportunity for mistakes at each end of the line.

THE Director of the Batavia Observatory, Dr. Van der Stok, has published the monthly and yearly rainfall values of the East Indian Archipelago for 1897—the nineteenth year of the series. The stations number 215; in Java the rainfall of the year was less than the average, but in Sumatra the amount was greater than the mean, especially during the first part of the year. One of the tables shows the greatest quantity of rain in twenty-four hours during each month, for the years 1879–97; at Batavia and several other places the fall amounted to over 11 inches, and in the south of the island of Saparoea to nearly 16 inches.

PROF. L. ERRERA, of Brussels, reprints from the *Bulletin* of the Royal Academy of Belgium an account of experiments made on *Aspergillus niger*, which he claims to prove indisputably that an acquired character—viz. adaptation to the medium in which it grows—is transmitted by inheritance.

THE part of the *Minnesota Botanical Studies* for February is full of interesting matter. Besides papers of more local interest, are articles on seedlings of certain woody plants, and on the comparative anatomy of hypocotyl and epicotyl in woody plants, by Mr. F. Ramaley; a contribution to the life-history of *Rumex*, by Mr. Bruce Fink; one on seed dissemination and distribution of *Razoumofskia robusta*, a parasitic plant belonging to the Loranthaceæ, by Prof. D. T. MacDougal; also observations on *Gigartina*, by Mary E. Olson, and on *Constantinea*, by Mr. E. M. Freeman.

PROF. F. PLATEAU, of Ghent, pursues his adverse criticism of the theory that insects are mainly attracted to flowers by the sense of sight in their capacity as pollen-distributors. In a paper, reprinted from the Memoirs of the Zoological Society of France, he details a series of observations on *Salvia horminum* and *Hydrangea opuloides*. Neither the coloured bracts of the former, nor the conspicuous sterile flowers in the latter species, can be regarded as "vexillary." In both

cases the pollinating insects make their way at once to the flowers which contain the honey, without being visibly guided by the showy organs in either case; while, if these are removed, it does not appear to make any material difference in the number of insects which visit the inflorescence.

THE conception of vast magnitudes forms the basis of two papers in *Die Natur* for April, by H. Sonnenschmidt, entitled "A Glance at the Kingdom of Large Numbers."

"MOSQUITOS AND MALARIA" form the basis of an article by Dr. F. Mesnil, in the *Revue générale des Sciences*, on the hæmatozoa of marsh fevers. The paper is illustrated by figures showing the different stages of the hæmatozoa both of man and of birds.

IN two papers communicated to the *Verhandlungen* of the German Physical Society, C. Liebenow applies the principles of thermodynamics to calculate the thermo-electromotive force of metal conductors, and compares the results of theory and experiment.

The Horseless Age, a New York journal devoted to the interest of the motor vehicle industry, is now, at the beginning of its fourth year, issued weekly instead of monthly. The first number of the new volume contains a paper by Mr. Hudson Maxim, on "Some thermodynamics of vehicle motors," and an editorial discussion on the question "Shall vehicle motormen be licensed?"

AN extension of the methods of integration of Monge and Ampère is worked out by G. Vivanti in the *Rendiconti del R. Istituto Lombardo*, xxxii. 6. The present paper contains a generalisation for any number of variables of certain investigations of the types of partial differential equations of the second order which satisfy conditions of integrability, the corresponding system of conditions in the case of three variables having been investigated previously by Vivanti, whose results have been generalised by Forsyth.

IN a communication to the *Bulletin* of the Cracow Academy, No. 2, M. K. Zorawski applies the method of conformal representation to the convergency of Lagrange's, Bürmann's, Hoene-Wronski's, and other series derivable from Taylor's theorem. The same writer also discusses the geometry of certain infinitesimal transformations and differential expressions which do not possess the property of remaining invariable under the given transformations. This number of the *Bulletin* also contains papers by S. Kepinski on the integrals of solutions of certain equations of the second order with three singular points.

IN *Terrestrial Magnetism* for March 1899, Dr. L. A. Bauer gives two papers, one on the physical decomposition of the earth's permanent magnetic field, and the other a preliminary note on the question, "Is the principal source of the secular variation of the earth's magnetism within or without the earth's crust?" The object of the first paper is to resolve the earth's so-called permanent field into component ones physically interpretable. In it the author arrives at the somewhat striking conclusion that the unsymmetrical distribution of the earth's magnetism, and the unsymmetrical distribution of temperature as exhibited on the earth's surface, on the average for the year, are in some way related to each other.

PROF. H. POINCARÉ, writing in the *Revue générale des Sciences*, deals with certain considerations connected with the theory of probability. The author, from consideration of various problems, points out that in all probability calculations it is necessary to take as starting-point some hypothesis or convention which is always to a certain degree arbitrary. The most frequent hypothesis is the doctrine of continuity, and the most satisfactory calculations are those in which the result is independent of the hypothesis made at the commencement, provided that this hypothesis satisfies the conditions of continuity.

DR. H. J. OOSTING, writing in the *Zeitschrift für den physikalischen und chemischen Unterricht*, describes several contrivances for exhibiting the resultant of two circular or elliptic vibrations of different periods. In these a beam of light is reflected in succession from two mirrors, which are made to rotate about axes nearly but not quite perpendicular to their planes, the two rotating systems being connected by cogged wheels or an endless band, by which the ratio of the periods of rotation is defined, and the path of the resultant motion is shown by allowing the doubly-reflected beam to fall on a screen. The curves produced by composition of *two* circular or elliptic motions could be drawn by a much simpler apparatus, consisting essentially of a jointed pendulum capable of vibrating in all directions; but we would suggest that Dr. Oosting's method might be applied to tracing the various forms obtained by compounding *three* or more circular motions whose periods are in the ratio of different whole numbers.

SLOWLY but surely the photographic film is taking the place of the glass plate for many purposes, and its introduction now into the physical and astronomical laboratory is an important indication of its progress. Being light and flexible, and as sensitive and durable as glass plates, the two first-named properties render it of great service where weight and curved fields have to be dealt with. To determine the value of films where it is difficult to use the ordinary glass plate, Sir Norman Lockyer has lately been experimenting, and very successfully, with them, with the idea of adapting them to spectroscopic photography. The large concave Rowland grating now in use for solar spectroscopic photographs, has 20,000 lines to the inch ruled on its surface, and is of 21½ feet radius, giving a spectrum of 30 inches long. The focal plane of this grating is of necessity considerably curved; in fact, the plane of accurate definition at the edges of the field is about 0·5 inch in front of the similar plane at the centre. It is, therefore, impossible to get a sharp photograph of the whole spectrum on a glass plate; in fact, not more than 18 to 20 inches of the spectrum can be brought into focus on the same plane. This difficulty is, of course, got over by the use of a flexible film, which can be bent to the curvature of the field. The Kodak Company have sent us a print of one of Sir Norman's photographs taken with this Rowland concave grating. It is 30 inches long, and shows the arc spectrum of iron with a comparison spectrum of the sun from wave-length 3600 to 5200, and the lines are beautifully sharp from one end to the other. Sir Norman Lockyer also hopes that by using films, instead of glass plates, at the next solar eclipse, he will be able to obtain a greatly increased number of photographs, owing to the rapidity with which the film can be shifted in the short space of time available for photographic operations. At the last eclipse the photographic work was concentrated on obtaining a series of photographs of the chromosphere, both about the time of beginning and end of totality. By careful drill Mr. Fowler and Dr. W. J. S. Lockyer were both able to secure ten photographs at each of these important periods, the time occupied in making each series of ten exposures being twelve seconds. An apparatus for carrying films is also being designed, which can be adapted to the spectroscopic cameras at present in use in the laboratory and observatory.

AT the recent meeting of the Institution of Mining Engineers, the use of high-pressure steam as a possible substitute for gunpowder or other dangerous explosives in coal mining was suggested by Major-General H. Schaw, C.B. Broadly, the suggestion is that a cartridge of pure water lodged in a shot-hole

should be converted into steam at about 150 pounds per square inch pressure by means of electricity of low tension; the cartridge or boiler to be made of such strength that it would burst at about this pressure, when the force set at liberty would break down the coal. As an approximation, Major-General Schaw points out that a water-cartridge 1¾ inches in diameter and 3½ inches long, to be used in a 2-inch blast-hole, would hold about 8·4 cubic inches of water. It would be converted into high-pressure steam, and burst the cartridge in about one minute with the electrical power which the author suggests, and would thus exert a sudden force of about 1½ tons. The calculations which the author has made on the subject, and a sketch of a form of cartridge which embodies the principles of the suggestion, accompany the paper.

A LEAFLET, prepared and issued by Mr. John Plummer, Sydney, New South Wales, brings together a number of interesting facts referring to Australian birds. Although Australia has no native song birds like the nightingale, lark, thrush, or linnet, it possesses a great variety of feathered species, several of great beauty, and many possessing features of interest. Many birds known in Europe are plentiful in New South Wales. Among these are eagles, hawks, owls, swifts, swallows, martins, fly-catchers, pelicans, sand-pipers, plovers, ducks, grebes, petrels, gulls, terns, penguins, and albatrosses. The number of ducks on the inland rivers and lagoons is at times surprising. The Rev. J. E. Tenison Woods says he has travelled in winter along the river Murray, and the long estuary of the Coorong, and for upwards of 120 miles was never out of sight of large flocks, which literally darkened the air and water. The sparrow, as in other countries, is the pest of the farm and orchard in New South Wales. So long as there is plenty of seed and fruit the bird does not trouble itself about insects, but leaves it to its insectivorous brethren. Every kind of British cage-bird thrives in the colony, but when liberated they often have to fight for existence with the native species.

MESSRS. SWAN SONNENSCHEIN AND CO. announce the forthcoming publication of "Curiosities of Light and Sight," by Mr. Shelford Bidwell, F.R.S.

DURING May the following lectures will be given on Tuesday evenings at the Royal Victoria Hall, Waterloo Road, S.E.:—May 2, Mr. E. S. Prior, "The Art and Practice of Garden-making"; May 9, Mr. R. Kerr, "Picturesque Ireland"; May 16, Prof. Beare, "Curiosities of Insect Life."

SOME members of the Avicultural Society are organising a Postal Club for the encouragement of bird and animal photography. The co-operation of photographer-naturalists is invited. Address Mr. Chas. Louis Hett, hon. secretary *pro tem.*, Springfield, Brigg.

MESSRS. DUCKWORTH AND CO. are about to publish a book on natural selection, by Mr. Frederick Wollaston Hutton, F.R.S., entitled "Darwinism and Lamarckism." The object of the work is to give a concise account of the origin and growth of the Darwinian doctrine, including its most recent developments.

THE inspiring "Hunterian Oration" recently delivered at the Royal College of Surgeons of England, by Sir William MacCormac, Bart., K.C.V.O., has been published in volume form by Messrs. Smith, Elder, and Co. An abstract of the address has already appeared in these columns (p. 402); but every student of medical science should read the address in full, in order to understand the influence of Hunter's work upon modern surgery.

MESSRS. R. AND R. BECK, LTD., have issued a new catalogue of the Frena hand camera, and will send a copy to any one on application. The good qualities of the Frena are known to many photographers, and the selection of pictures in the catalogue shows that fine results can be obtained with this form of camera.

AN illustrated international monthly magazine of photography, published in four languages, and entitled *Camera Obscura*, will make its appearance in June. The magazine will be under the chief editorship of J. R. A. Schouten, the assistant editors being: French Section, Maurice Bucquet; German Section, R. Ed. Liesegang; English Section, Max Sterling; Dutch Section, Chr. J. Schuver. The publishers will be Messrs. Binger Bros., Amsterdam; and the publishers for Great Britain and the Colonies, Messrs. Williams and Norgate.

AMONG the new features of the 1899 edition of "The Statesman's Year-Book" (Macmillan), edited by Dr. J. Scott Keltie, with the assistance of Mr. I. P. A. Renwick, are a map of Africa showing railways, navigable waters, and distances from coast, and one showing telegraphs and political divisions; a map of Newfoundland, illustrating the French shore question; and a map showing the addition on the Chinese mainland to the colony of Hong Kong. There are also preliminary tables showing the revenue, expenditure, debt, and debt-charge of the principal countries of the world, with the commerce of these countries in figures and per head of population; and a table showing the gold and silver production of the world. The events of the past year have necessitated a number of alterations, and the additions have increased the volume from 1166 to 1248 pages. No one interested in political geography can dispense with this annual statement of the position of the countries of the world.

MM. GEORGES CARRÉ AND C. NAUD, Paris, have commenced the publication, under the general title "Scientia," of a handy collection of monographs, by distinguished investigators, on important scientific questions. The collection is divided into two series, one containing papers on physical science, and published under the direction of MM. Appell, Cornu, d'Arsonval, Friedel, Lippmann, Moissan, Poincaré, and Potier; and another series containing biological papers edited by MM. Balbiani, d'Arsonval, Filhol, Fouqué, Gaudry, Guignard, Marey, and Milne-Edwards. In the first volume of the physical series, M. Poincaré gives a simple account of Maxwell's theory and Hertzian oscillations. In the first volume of the biological series, Prof. Bard deals with "La spécificité cellulaire," referring particularly to the consequences of this doctrine in biology. The second volume in this series, by Dr. F. le Dantec, is on sexuality. Only these three volumes have so far appeared, but a number of others are in preparation, and will shortly be published. Each volume will be complete in itself, and the complete set of monographs will make a convenient library of modern scientific work and opinion.

THE additions to the Zoological Society's Gardens during the past week include two Himalayan Monauls (*Lophophorus impeyanus*, 2 ♂) from the Himalaya Mountains, presented by Mrs. Barnewell Elliot; a Black-shouldered Kite (*Elanus caeruleus*) from Ceylon, presented by Mr. J. D. Waley; a Macaque Monkey (*Macacus cynomolgus*, var.) from India, a Brazilian Tapir (*Tapirus americanus*, ♂) from Peru, a Great Bustard (*Otis tarda*), European; three Anoas (*Anoa depressicornis*, ♂ ♂ ♀) from the Celebes, deposited; two Brush Turkeys (*Talegalla lathami*), three Pectoral Quails (*Coturnix pectoralis*), a Varied Hemipode (*Turnix varia*) from Australia, two green Glossy Starlings (*Lamprocolius chalybeus*) from North-east Africa, two White-backed Trumpeters (*Psophia leucoptera*) from the Upper Amazons, purchased; five Barbary White Sheep (*Ovis tragelaphus*, 2 ♂, 3 ♀), a Yellow-whiskered Lemur (*Lemur xanthomystax*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

ASTRONOMICAL OCCURRENCES IN MAY :—

May 2-6. Meteoric shower before sunrise from Aquarius.
4. Tuttle's comet in perihelion.
8. 11h. 6m. Minimum of Algol (β Persei).
13. 8h. 47m. to 10h. 12m. Transit of Jupiter's Sat. III.
16. Swift's comet closely S.W. of o Andromedæ (mag. 3·8).
20. 12h. 5m. to 13h. 36m. Transit of Jupiter's Sat. III.
24. 10h. 15m. to 11h. 25m. Occultation of B.A.C. 5254 (mag. 5·4) by the moon.
26. 11h. 39m. to 12h. 39m. Occultation of 7 Sagittarii (mag. 5·4) by the moon.
26. 12h. 3m. to 13h. 15m. Occultation of 9 Sagittarii (mag. 5·7) by the moon.
27. 2h. Uranus in opposition to the sun.

TUTTLE'S COMET (1899 *b*).—The following positions are continued from the ephemeris by Herr J. Rahts in *Astr. Nach.* (Bd. 149, No. 3555) :—

Ephemeris for 12*h. Berlin Mean Time.*

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br.
April 27 ...	4 32 53·4 ...	+13 27 35 ...	1·86
28 ...	36 20·6 ...	12 59 33	
29 ...	39 47·2 ...	12 31 20	
30 ...	43 13·3 ...	12 2 56 ...	1·89
May 1 ...	46 38·9 ...	11 34 21	
2 ...	50 4·0 ...	11 5 35	
3 ...	53 28·8 ...	10 36 39	
4 ...	4 56 53·1 ...	+10 7 33 ...	1·90

TEMPEL'S COMET (1873 II.).—The following search ephemeris is given by M. L. Schulhof in *Ast. Nach.* (Bd. 149, No. 3554) :—

Ephemeris for 12*h. Paris Mean Time.*

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br.
April 27 ...	18 36 50·4 ...	− 5 13 22 ...	0·370
28 ...	38 35·2 ...	5 8 45	
29 ...	40 19·6 ...	5 4 11	
30 ...	42 3·8 ...	4 59 39 ...	0·405
May 1 ...	43 47·6 ...	4 55 11	
2 ...	45 31·1 ...	4 50 46	
3 ...	47 14·2 ...	4 46 25	
4 ...	18 48 57·0 ...	− 4 42 8 ...	0·460

DOUBLE-STAR CATALOGUE.—*Ast. Nach.* (Bd. 149, Nos. 3557 and 3558) contain a catalogue of 132 new double-stars which have been discovered by Prof. G. W. Hough, with the 18½-inch refractor of the Dearborn Observatory, Illinois, U.S.A. This is the fourth catalogue of new double-stars issued from the same observatory, the total number now reaching 622. The measures have been made during the period 1894 to 1897, each pair having been measured on two or more nights. Magnifying powers of 390 and 925 have been most frequently employed. It is noted that one of the stars, No. 580 in the catalogue, is probably a binary, successive measures having indicated motion between the components. This star is Lalande 37881, and its position for 1880 is R.A. 19h. 47m. 19s. ; Decl. + 22° 9′. The change of position angle, on which the probability of its being a binary is based, is shown in the following table :—

Date.	Position angle.	Distance.	Magnitudes.
1895·76 ...	267·6 ...	0″·65 ...	8—8·1
1897·62 ...	276·0 ...	0″·68 ...	8—8·2

LAW OF TEMPERATURE IN GASEOUS BODIES.—The *Astronomical Journal* (No. 459) contains some further criticisms on Dr. See's article on "The Sun's Heat" (*A. J.*, No. 455) by Mr. C. M. Woodward, of Washington University. The points he brings forward are as follows :—

(1) Dr. See assumed his hypothetical gaseous globe to have a definite boundary, but there is no good reason to suppose that a pure gas, unrestrained save by the mutual attraction of its particles, has a definite limiting surface.

(2) The assumption that the *pressure* at R_0 is directly measured by the weight of an element of mass is wrong ; it is the *variation* in the pressure which is measured by the weight.

(3) Instead of the intensity of pressure varying *inversely* as the fourth power of the radius, as given by Dr. See, it really varies inversely as the square, or $P = \frac{A}{R^2}$.

(4) The final derivation of the formula $T = \frac{K}{R}$ is false, because the value of P, by which it is determined, is wrong. "Dr. See appears to forget that when the volume of a given gas is fixed by other considerations, the pressure is independent of the force of gravity. He leaves the question of temperature still unsolved. Instead of finding the temperature from the pressure, the temperature is to be determined by the principle that the change of temperature during contraction must be such as to render the force of mutual attraction sufficient to do the work of compression. For a solution of that problem, I beg leave to refer to my paper read before the Saint Louis Academy of Science, March 20, 1899."

RETURN OF HOLMES' COMET (1892 III.).—Mr. H. J. Zwiers gives in *Ast. Nach.* (Bd. 149, No. 3553) a detailed ephemeris for the expected return of this comet, which he calculates will pass perihelion on April 27. This not being quite certain, he also gives the positions corresponding to perihelion passages on April 19 and May 5. We append the positions for T = April 27·6651 :—

Ephemeris for 12*h. G.M.T.*

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br.
April 28 ...	23 59 25·3 ...	+ 4 0 15 ...	0·0272
30 ...	0 3 0·8 ...	4 37 29	
May 2 ...	6 35·7 ...	5 14 44	
4 ...	10 10·1 ...	5 52 1 ...	0·0280
6 ...	13 43·8 ...	6 29 19	
8 ...	17 17·0 ...	7 6 37	
10 ...	20 49·5 ...	7 43 54	
12 ...	24 21·4 ...	8 21 11 ...	0·0290
14 ...	27 52·7 ...	8 58 25	
16 ...	31 23·3 ...	9 35 39	
18 ...	0 34 53·2 ...	+10 12 50 ...	0·0298

THE THEORY OF THE RAINBOW.

MOST text-books still explain the rainbow phenomena with the aid of Descartes' "effective" rays. This explanation concerns only the principal and the secondary bows ; it does not take notice of the supplementary bows, nor of the fact that the colours, their intensity, breadth, and sequence vary greatly with the size of the raindrops. That the rainbows are interference phenomena, was recognised by Young. Their correct theory is contained in Airy's "Intensity of Light in the Neighbourhood of a Caustic" (*Trans. Cam. Phil. Soc.*, vi. p. 379 ; viii. p. 595, 1838 and 1848). The intensity depends upon an infinite integral, which Airy first attempted to compute by quadratures. Stokes found a more convenient form for his integral. The theory was first verified by W. Hallows Miller in 1871 ; later by Boîtel, Mascart, and others. In 1896, Prof. J. M. Pernter, then at Innsbruck, now director of the Central Station for Meteorology and Earth Magnetism at Vienna, presented a long paper on the colours of the rainbow and the white rainbow to the Vienna Academy (*Wien. Akad. Ber.*, 106, ii. *a*, p. 137, 1897). The paper involved very laborious calculations and experiments, and dealt fully with the influence of the size of the raindrops ; it was referred to in NATURE, January 27, 1898. In the Jubilee number of the *Zeitschrift für Oesterreichische Gymnasien*, December 1898, Pernter has now made an attempt to render Airy's theory intelligible to the pupils of secondary schools.

The importance of the angle of minimum deviation is explained with the help of the diagram (Fig. 1). Not to complicate the figure, the rays are all supposed to correspond approximately to Fraunhofer's line C in the red-orange. With increasing angle of incidence, the deflection of the refracted ray from its original direction becomes greater and greater, until a maximum is reached (the dotted ray) ; on further increasing the angle of incidence, the deviation decreases again.

That this is so, is shown in tables giving angles of incidence, refraction, and the resulting final deviation, and is further explained by a simple trigonometrical deduction. The reflected and refracted rays emerge, not parallel to one another, but divergent or convergent. The limiting ray of minimum deviation, and the rays in its immediate neighbourhood and approximately parallel to it, would be the "efficient" rays of Descartes. They have their significance, though not that which Descartes ascribed to them. For the C rays, this angle (which corresponds to an angle of incidence of 59° 24′) is 42° 4′; that is to say, the red-orange arc of the primary bow is seen under that angle. Multiple reflection within the raindrops renders an infinite number of other such limiting rays possible. The emerging rays would emanate from various quadrants. We should hence see bows, not only when standing with our backs to the sun, but also when a cloud is between our eyes and the sun (*e.g.* in the case of three and four internal reflections). The direct sunlight would prevent our seeing those bows, but they can be observed and shown in class-rooms when we let the light fall on cylindrical glass rods after Babinet's fashion. With cylinders instead of spherical drops, we see, of course, a series of vertical coloured bands, arranged in a horizontal line, instead of arcs. Miller, experimenting with water streams, measured thirty such monochromatic bands. Pernter describes a simpler arrangement, and calculates, in his popular treatise, the angles of minimum deviation for fifteen bows, both for water and glass. Experimenting with white light and water streams, 1 mm. and less in diameter, he counted with 1 mm. drops one bow and twenty-four secondaries (supplementary bows) of beautiful colours (white in the twelfth, after which the sequence of the colours is reversed), and with drops of 0·5 mm. eleven bows and secondaries and some more bands of indistinct colour (white in the fifth).

We recognise from Fig. 1 that the emerging wave has not a straight front like the entering spherical wave AB, but a peculiarly curved front, represented in exaggerated curvature in Fig. 1*a*. Such a wave must give rise to interference phenomena, and all the rainbows, not only the supplementary (or so-called spurious) bows, are really diffraction phenomena of a peculiar kind. That part of the wave-front which is nearest to the ray of minimum deviation might be called the effective wave-front. In order to arrive at an equation for that part, Pernter starts from Wirtinger's consideration that, if s_1, s_2, and s_3 are the paths of a ray, in the air, in the water and again in the air, reckoned between the entering and the emerging wave-fronts, and c_1 and c_2 the velocities of light in air and in water, then $\frac{s_1}{c_1} + \frac{s_2}{c_2} + \frac{s_3}{c_1} =$ const. for all rays of that wave. The constant can be chosen at will; he takes the value $\frac{a}{c_1}$, in which a is the radius of the drop. Under the assumption that the curve consists of two spherical arcs, one concave, the other convex, Pernter then calculates the phase difference after Mascart. As regards the amplitude, however, of his intensity equation, he has to refer back to Airy; but he succeeds in showing that each colour of the rainbow consists of an infinite number of coloured rings of decreasing intensity, separated by rings of intensity 0. Pernter objects to the term "spurious" rainbows, since they are as much rainbows as the ordinary bows; his own terms, Hauptbogen, Nebenbogen, secundäre Bogen (principal bow, by-bow, secondary bows) are not suitable for literal translation. When we replace the prism of a spectroscope by a glass rod, 2 mm. in diameter, and set the telescope under 22° 51′ (principal bow for glass), we see a series of red bands as mentioned. If this angle is not convenient, we adjust the instrument for one of the other bows. The first is by far the brightest; after the eighth maximum the intensity diminishes very slowly; Airy's original curve brings this out very clearly. Replacing the rod by one, less than 1 mm. in diameter, we notice that the colours are different and less bright; the blue, absent in the first experiment, is prominent, and all the bands are broader than before. Smaller raindrops give broader bows, but, owing to their diminished intensity, their number appears smaller. Fig. 2 is Pernter's colour curve for raindrops 0·5 mm. in diameter. The size of the actual raindrops lies, for our latitudes, between 0·05 and 2 or 3 mm. diameter. The fog-bow is produced by the sun when shining on the water globules, 0·05 mm. and less in diameter, of fine mists. We notice that we get real white in the bow by superposition of the colours. This is possible for drops of all sizes, and must occur with very small drops. The sequence of the fog-bow colours is: very faint yellow, whitish yellow, bright white, whitish violet; colourless gap; then (secondary bows) faint whitish blue, white, whitish red. To imitate these mists, Pernter fixed a glass tube, 0·5 mm. in diameter, in a lead pipe connected with the high-pressure water mains, and directed the jet against a metallic plate; the mist thus produced consisted of drops 0·0106 mm. in diameter. McConnel (*Phil. Mag.*, 29, p. 453, 1890), who made calculations for raindrops of certain sizes in 1890, describes eighteen fog-bows, observed by Osmond in 1886–87 on Ben Nevis; of these, ten were double. Exact measurements of rainbows are exceedingly scarce. Pernter differs from McConnel as regards the border colours of fog-bows; he also doubts that the pale colour of fog-bows can be due to the uneven sizes of the drops, because the accompanying phenomena, glories, require homogeneous conditions. But dilution with white light, of course, makes all colours appear whitish.

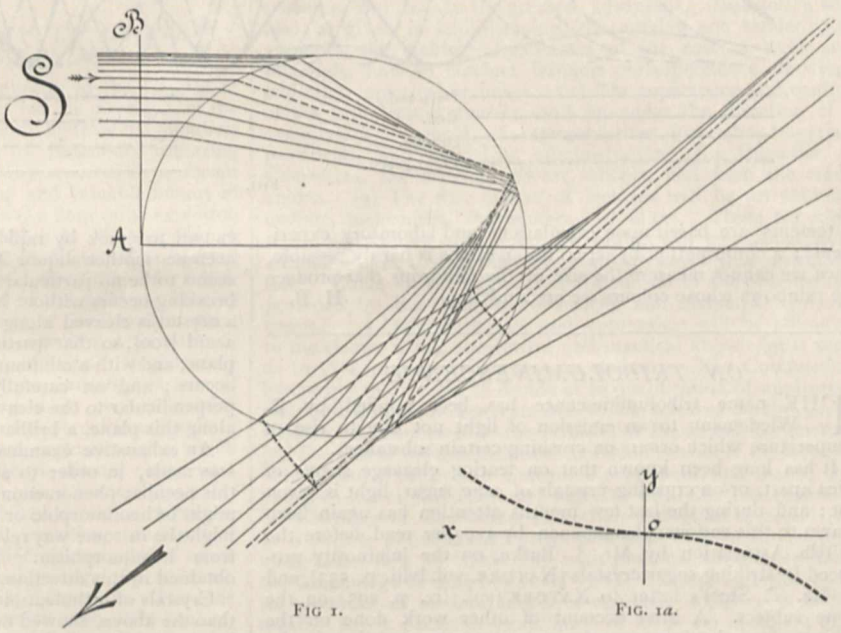


FIG. 1.

FIG. 1*a*.

Pernter's conclusions are interesting to meteorologists. The greater the drops, the more secondary bows. Bright pink and green, without blue, indicate drops from 1 to 2 mm. in diameter; intense red occurs with big drops only, but the maximum intensity is really in the violet. Drops of 0·5 mm. give secondaries consisting of green and violet (and also blue, which, however, is masked by contrast) immediately joining the principal bow. Yellow in the secondary would mean drops of 0·3 mm. and, if there are separating gaps, of 0·2 mm. Drops of diameters between 0·17 and 0·4 mm. show the greatest variety of colours, also in the secondary bows; but real red is absent. When we notice five and more secondaries of striking breadth

without white and without gaps, we have probably drops of 0·1 mm. ; in smaller drops, gaps and white make their appearance. A real white bow with yellow or orange and blue margins requires drops of not more than 0·05 mm. Moonbows appear white owing to their feeble intensity. A small change in the size of big drops does not much matter. These

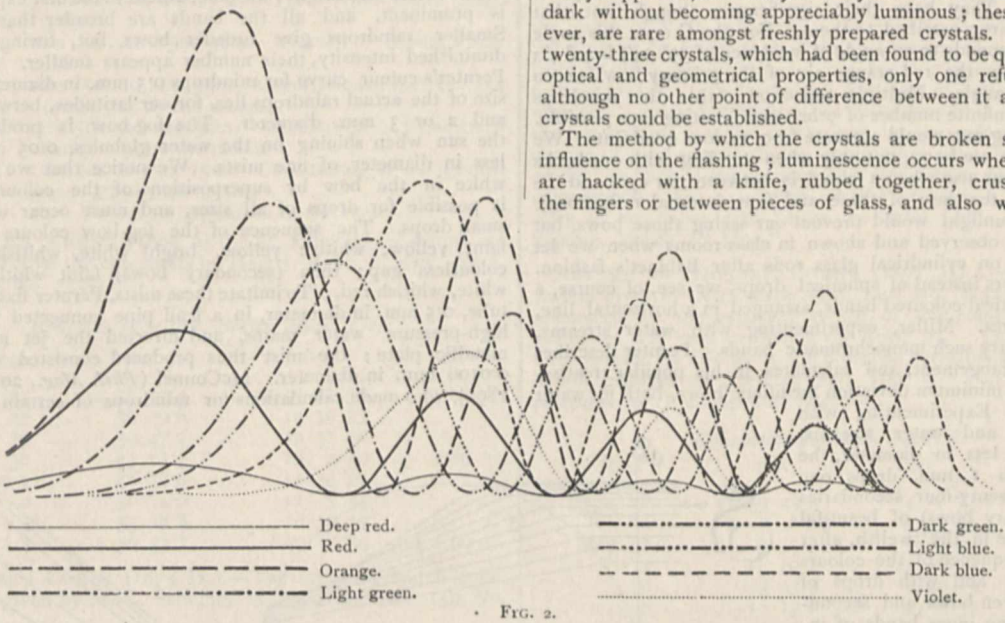


FIG. 2.

statements are based upon calculations and laboratory experiments ; a confirmation by actual observations is hardly possible, since we cannot measure the size of the raindrops that produce the rainbows whose colours we are studying. H. B.

ON TRIBOLUMINESCENCE.

THE name triboluminescence has been applied by E. Wiedemann to an emission of light not due to rise of temperature which occurs on crushing certain substances.

It has long been known that on tearing cleavage sheets of mica apart, or on crushing crystals of cane sugar, light is given out ; and during the last few months attention has again been drawn to this curious phenomenon by a paper read before the British Association by Mr. J. Burke, on the luminosity produced by striking sugar crystals (NATURE, vol. lviii. p. 533), and by Mr. T. Steel's letter to NATURE (vol. lix. p. 295) on the same subject. A brief account of other work done on the subject of triboluminescence during recent years may therefore be of interest.

Some years ago I contributed a paper to the Chemical Society (*Trans. Chem. Soc.*, 1895, 985) on orthobenzoicsulphinide $C_6H_4\langle^{SO_2}_{CO}\rangle NH$, the substance known commonly as saccharin, and which is now largely used as a substitute for sugar when the use of the latter is considered undesirable upon medical or other grounds. I showed that commercial saccharin crystallises, on spontaneous evaporation of its solution in acetone, in large, transparent, monosymmetric crystals having the geometrical constants :—$a : b : c = 2{\cdot}7867 : 1 : 1{\cdot}7187$, $\beta = 76° 8' 30''$. On breaking or crushing the freshly prepared crystals, they emit a very vivid, bluish-white light, which, however, is only of momentary duration. This flashing or phosphorescence of the crystals is very brilliant, and is quite noticeable even in a well-illuminated room. The luminescence was, in fact, first noticed whilst the crystals were being manipulated in the full glare of an incandescent gas lamp. The phosphorescence may be well shown on a small scale by pulverising a crystal between two microscope slides, and on a larger scale by vigorously shaking a bottle of the crystals in a dark room ; on grinding a quantity of the material in a glass mortar in the dark, an almost continuous, though rather fainter, luminescence is observed. On closely watching large transparent crystals whilst crushing them, the illumination appears to consist of a glow which pervades the whole crystal just as it breaks, and then immediately disappears ; the emission of light consequently occupies so short a time as to appear instantaneous. The luminescence is not always apparent, and a crystal may sometimes be crushed in the dark without becoming appreciably luminous ; these cases, however, are rare amongst freshly prepared crystals. On crushing twenty-three crystals, which had been found to be quite normal in optical and geometrical properties, only one refused to flash, although no other point of difference between it and the other crystals could be established.

The method by which the crystals are broken seems without influence on the flashing ; luminescence occurs when the crystals are hacked with a knife, rubbed together, crushed between the fingers or between pieces of glass, and also when they are caused to crack by rapid heating, either in the air or in the acetone mother liquor from which they crystallise. There seems to be no particular plane in the crystal parallel to which breaking occurs without luminescence ; no matter how carefully a crystal is cleaved along the very perfect cleavage on the pinacoid {100}, so that parting only occurs parallel to the cleavage plane, and with a minimum of shock, vivid luminescence always occurs ; and on carefully cutting the crystals in directions perpendicular to the cleavage, so that very little parting occurs along this plane, a brilliant flash almost invariably results.

An exhaustive examination of the properties of the crystals was made, in order to allow of some cause being assigned to this peculiar phenomenon ; it was at first thought that the crystals might be hemimorphic or hemihedral, and that the luminescence might be in some way related to the polar properties inseparable from hemimorphism. No positive evidence was, however, obtained in this direction.

Crystals of orthobenzoicsulphinide, obtained by other methods than the above, showed no triboluminescence. The substance on heating sublimes in long glistening needles, which are morphologically and optically identical with the crystals deposited from acetone, but show no triboluminescence.

After the publication of the paper referred to, Luigi Brugnatelli (*Zeits. f. Krystallographie*, 1897, **27**, 78) gave particulars of several similar cases found by him amongst derivatives of santonin prepared by Amerigo Andreocci (*Atti d. R. Accad. Linc.*, 1895, [5*a*], **2**, 28). The monosymmetric crystals of ethylisodesmotroposantonin, $C_{12}H_{13}(OEt)\langle^{O.C:O}_{CHMe}$, emit a yellow luminescence when crushed ; the monosymmetric crystals of the enantiomorphously related dextro- and lævo-ethylic santonite, $C_{12}H_{14}(OH)CHMe.COOEt$, and the monosymmetric crystals of lævodesmotroposantonous acid, $C_{12}H_{14}(OH)CHMe.COOH$, all give a yellowish-green triboluminescence. Lævoethyldesmotroposantonous acid $C_{12}H_{14}(OEt)CHMe.COOH$, crystallises in hemihedral anorthic crystals, which when crushed glow with a beautiful emerald-green light.

Crystals of saccharin have also been examined by W. Arnold (*Zeits. f. Kryst.*, 1896, **27**, 92), who describes their triboluminescence as "stark," and states that that of crystallised hippuric acid $C_6H_5.CO.NH.CH_2.COOH$, is "sehr stark."

Since the publication of my paper in 1895, I have made a few observations of interest to which I may now refer. Crystals of saccharin which, when freshly prepared, flash brilliantly on crushing, gradually lose this property, and after a few weeks' preservation show no appreciable triboluminescence. Further, in order to obtain crystals which exhibit a brilliant triboluminescence, the impure commercial saccharin must be crystallised from acetone; a carefully purified specimen of saccharin, when crystallised from acetone, yielded crystals which do not phosphoresce at all when broken. Both of these points are of great importance as affording possible clues to the cause of this strange property; it would be of interest to ascertain whether the triboluminescence of cane sugar, hippuric acid, and other substances is in any way characteristic of the freshly prepared crystals, and is dependent on the presence of traces of impurity. Another point of great interest, indicating that triboluminescence is probably not a property of the chemical molecules, but only of the crystalline structure, is noted in Brugnatelli's paper; although the crystals of dextro- and lævo-ethylic santonite show brilliant triboluminescence, the anorthic crystals of the racemic compound of these two substances exhibit no triboluminescence.

In concluding this note on triboluminescence, may I point out that the study of the subject from a physical standpoint should be extremely fertile. Saccharin may now, thanks to commercial enterprise, be obtained in large quantities at a comparatively low cost.

WILLIAM JACKSON POPE.

EXPLOSIONS CAUSED BY COMMONLY OCCURRING SUBSTANCES.

THE occurrence of a serious explosion in the Capitol at Washington, last November, has led the President of the American Society, Prof. C. E. Munroe, to address the members on the subject of explosions caused by commonly occurring substances. The address, which is fully reported in a recent number of *Science*, forms an interesting and valuable history of the subject, beginning with the well-known flour mills explosion in Glasgow in 1872. A similar explosion in Minneapolis, in 1878, shattered walls six feet thick at the base, and projected sheets of corrugated iron to a distance of more than two miles. The origin of the explosion was traced to the striking of fire by a pair of mill-stones through the stopping of the "feed." Dust explosions have also been recorded in connection with oatmeal, starch, rice, malt, spice, saw-dust, soap and zinc. In pharmacy and the arts accidents have arisen from various mixtures of combustible substances and oxidising agents in connection with matches, chlorate of potash lozenges, sodium peroxide and sodium bisulphite mixtures. Among substances explosive *per se* which have given rise to accidents, are erythryl nitrate, ammonium nitrate, and various nitroso compounds, diazo bodies, diamides, hydrazoic acid and its compounds, hydroxylamines, chlorates, carbonyl compounds, permanganates, peroxides, chlorides and iodides. Prof. Munroe devotes a considerable amount of space to explosions arising from the use and storage of petroleum, drawing his information mainly from English sources. He adds to the examples, well known in connection with British shipping, of explosions caused by the use of "driers" and paints made up with volatile hydrocarbons. A remarkable explosion occurred at Rochester, New York, in 1887, owing to the leakage of twelve thousand gallons of naphtha from a dislocated iron main into a sewer. The explosive mixture of air and vapour was ignited from a boiler fire through an untrapped water-closet, and the explosion, besides causing loss of life, destroyed three large mills. Prof. Munroe states that of substances supposed to impart safety to kerosene, alum and sal-ammoniac are practically insoluble in the liquid, and are of no effect; whilst camphor, though it raises the flash-point, causes the vapour mixed with air to have a lower temperature of ignition.

After dealing with compressed gases and coal-dust explosions, Prof. Munroe reverts to the Washington explosion, and shows that it was due primarily to the escape of gas through a governor into a "live" 4-inch main, owing to a sudden doubling of pressure. The gas found its way through a labyrinth of passages and compartments in a section of the building, and when the stratum of gas reached down to the level of some burning gas jets, ignition took place and the explosion was propagated in all directions, its intensity and range being increased by the disturbance of large accumulations of inflammable dust.

TECHNICAL EDUCATION IN GERMANY.[1]

GERMAN merchants and manufacturers are alive to the importance of increasing the efficiency of the mechanics and artisans, and of improving the quality of their goods. According to the United States Consul at Hanover, they appear to be resolved that "Made in Germany" shall no longer pass as a term of opprobrium, but be a synonym of excellent materials and good workmanship. A meeting took place recently in Hanover, which is likely to exercise a very important influence in this direction. It was in the nature of a conference, under Governmental sanction and direction, to discuss German trade and manufacturing interests, and to devise plans for their extension and improvement. It was held at the instance of the Prussian Minister of Trade and Commerce, and was presided over by the Oberregierungs President of the Province of Hanover, Count Stolberg. Representatives of the Government from Berlin, the highest officials of the Hanoverian provincial and municipal administrations, leading manufacturers and business men, delegates from the Chamber of Commerce, the manual training and artistic trade schools, and from the working men's trade unions, attended and took part in the deliberations. As a result of the conference, it was unanimously resolved: (1) To establish at once in the city of Hanover advanced lecture courses, in which artisans and apprentices in all trades shall have an opportunity to complete their mechanical education, and be instructed by experts how to install and manage a model workshop, and work and use machines and tools to the greatest advantage. Instruction will also be given in book-keeping, the making and rendering of accounts, the making of estimates of the cost of work and materials, how to conduct business correspondence, drawing, and other practical branches. (2) The supervision and control of the said lecture courses shall be under the direction of a commission composed of representatives from the Imperial, provincial, and municipal administrations, the Chamber of Commerce, the manual and art schools, and from the trade unions. (3) The first course of lectures will be for cabinet-makers, locksmiths, shoemakers and tailors. Those for other trades will follow. (4) A fee for tuition will be exacted from mechanics able to pay, but those unable to pay will be instructed free. Funds for the payment of the tuition of the poor will be provided by the Hanover provincial and municipal Governments. (5) Only mechanics and apprentices will be admitted to the classes whose theoretical and practical knowledge is such as to give promise of success as students. The Commission has power in all cases to decide as to qualification of applicants for admission. (6) Teachers are to be selected by the Commission, and confirmed by the Minister of Trade and Commerce. (7) The cost of the establishment and maintenance of the lectures is to be supplied by the General Government, and that of the province and city of Hanover, together with the trades unions, the Chamber of Commerce, and others interested therein. (8) It is further intended that great care shall be used in teaching apprentices how to obtain the most practical advantages from the knowledge obtained by them in the classes. To this end, the creation of working-men's co-operative societies is to be urged. (9) A permanent exhibition of all power machines and tools used in the small trades is to be established in the Gewerte Halle (Industrial Hall) in Hanover. The machines exhibited there are to be worked by competent mechanics, who, on request, will exhibit their uses and management to all inquirers. In connection with the machine exhibition, there will also be established an exhibition of sample products, in process of manufacture, as well as finished. (10) In order to enable small manufacturers and tradesmen to purchase their raw materials at wholesale prices, and to facilitate the sale of their products, the formation of co-operative stores is to be encouraged. Consul Anderson has been informed that the establishment of these courses of lectures to mechanics is the initial move in a general plan to be in all the main labour centres of Germany, dependent upon the success of this experiment.

[1] Reprinted from the *Journal* of the Society of Arts (April 14).

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The following are the chief lectures advertised for the ensuing term in the Faculty of Natural Science, in addition to the elementary courses:—Prof. Gotch, on the nervous system; Dr. Mann, on histology of sense organs; Mr. Burch,

on dioptrics of the eye; Prof. Weldon, on Tunicata; Mr. Bourne, on the history of zoology; Mr. Thompson, on mammalian morphology; Prof. Sollas, on evolution of the earth and on palæontology; Mr. Walden, on allotropy; Prof. Miers, on isomorphism; Mr. Bowman, on rock-forming minerals; Prof. Tylor, on anthropology in classical literature. Among the mathematical lectures are:—Prof. Love, on gravitational attraction and theory of potential; Prof. Elliott, on theory of functions; Prof. Esson, on synthetic geometry of conics. Among the lectures in medicine are announced:—Prof. Thomson, on the urogenital system and anatomy of the placenta and embryonic membranes; Dr. Ritchie, on pathological bacteriology; Mr. Jerome, on medical pharmacology. The new Sedleian Professor of Natural Philosophy will also give an inaugural lecture on Thursday, April 27, on "The aims and methods of natural philosophy."

The recently appointed Wilde Reader in Mental Philosophy (Mr. G. F. Stout) will also deliver an inaugural lecture on Wednesday, April 26, on "Psychology as philosophy and as science."

An examination will be held on May 16 for the Abbott Scholarship, in the subjects of mechanics and physics, and chemistry. Candidates must be sons of clergymen of the Church of England, who stand in need of assistance.

CAMBRIDGE.—The honorary degree of Doctor of Science is to be conferred on Sir William Turner, Professor of Anatomy in the University of Edinburgh, and President of the General Medical Council; and on the Rev. Thomas Wiltshire, Emeritus Professor of Geology in King's College, London. The ceremony will take place to-day (April 27). Mr. H. Jackson, First-class Natural Sciences Tripos 1896–98, has been elected a Fellow of Downing College.

THE appointments of the Earl of Kimberley to be Chancellor of the University of London, in the room of Lord Herschell, deceased; and of Mr. John Arthur Thomson to the chair of Natural History in the University of Aberdeen, in succession to the late Prof. Henry Alleyne Nicholson, are formally announced in the *Gazette*.

THE Board of Education Bill was read a second time in the House of Lords on Monday. Referring to the Bill, and in reply to criticisms, the Duke of Devonshire explained that the Government considered it desirable to reorganise the Education Department completely before the new local authorities for secondary education were called into existence. He knew of no insurmountable reason why a measure dealing with those local authorities should not be introduced and passed next Session. As regards the consultative committee, he remarked that the Government does not propose that it shall have any statutory character. The committee is to be the creation of the Minister, who is to be responsible for its action; and its duties are to be such as the Minister, on his responsibility, entrust to it.

THE following gifts to educational institutions in the United States are announced in *Science*: Mr. William K. Vanderbilt has given 100,000 dollars to Vanderbilt University for the erection of a new dormitory on the campus.—It is reported that the sum of over 250,000 dollars has been subscribed towards an endowment for Brown University. A committee is endeavouring to collect 2,000,000 dollars, which it is intended to devote to strengthening the departments already existing in the University.—A Bill has passed the Kansas Legislature granting 55,000 dollars for the erection of a new chemistry building at the State University.—Miss Catherine Wolfe Bruce has, through Prof. J. K. Rees, given 10,000 dollars to Columbia University, to be used for the measurement and discussion of astronomical photographs. Miss Bruce's gifts to the department of astronomy amount to 22,100 dollars.

THE Technical Education Board of the London County Council will proceed shortly to award not fewer than five senior county scholarships which are of the value of 60*l*. a year, together with payment of tuition fees up to 30*l*. a year, and are tenable for three years at University colleges and advanced technical institutions. These scholarships are confined to residents within the Administrative County of London, and are open only to those whose parents are in receipt of not more than 400*l*. a year. Candidates should, as a rule, be under twenty-two years of age, though the Board reserves the right to give preference to candidates who are under nineteen years of age. The scholarships are intended to enable those students who cannot afford a University training to pursue advanced studies for a period of three years in the highest University institutions in the country. Senior scholars appointed by the Board are studying at Cambridge, at colleges of University rank in London and elsewhere, and in University institutions on the continent. The Board usually makes a certain number of grants of lesser value in addition to awarding scholarships. Candidates must apply before Monday, May 15, to the Secretary of the Technical Education Board, 116 St. Martin's Lane, W.C.

WITH reference to the paragraph which appeared in our last issue, in regard to the proposed foundation of a University for the West of England, we find that the suggestions of the Bishop of Hereford, the President of Bristol University College, appear to be receiving serious attention. The Bishop referred to the steps being taken in Birmingham so that Mason College may be incorporated as the University of Birmingham, and thus Birmingham become the home of a Midland University. He had come to the conclusion that within reasonable limits the multiplication of such University centres was a very real stimulus to the higher life of the community; and sometimes in his day-dreams he saw the time when they would have a University of Bristol, with the sister colleges, the University College and the Merchant Venturers' Technical College, spreading new life and intelligence not only throughout the vast community of the city, but to the West of England. In regard to this, Mr. G. H. Pope, Secretary to the Merchant Venturers, writes to the local papers, and after hoping that the Bishop's dream may come true, adds that it is one "towards the ultimate fulfilment of which everything that the Merchant Venturers do for securing the completeness and perfection of their College is, not quite unconsciously, tending."

A COPY of the Calendar of the School of Practical Science of the Province of Ontario, affiliated to the University of Toronto, has been received. There are five regular departments of instruction in the school, in each of which diplomas are granted, viz.:—Civil engineering (including sanitary engineering); mining engineering; mechanical and electrical engineering; architecture; analytical and applied chemistry. The regular course in each department is of three years' duration, and leads to the diploma of the school. Graduates electing to continue their studies for a fourth year are allowed to select two subjects from an approved list, and are required to confine their whole attention to these subjects during the fourth year. The subjects on this list are such as require a large amount of time to be devoted to laboratory and other practical work. During this year the student is required to prepare a thesis on some subject connected with his work. After complying with all requirements, the candidate receives from the University the degree of Bachelor of Applied Science (B.A.Sc.). Bachelors of Applied Science may, after three years spent in professional work, present themselves for the degrees of Civil Engineer (C.E.), Mining Engineer (M.E.), Mechanical Engineer (M.E.), or Electrical Engineer (E.E.), as the case may be, subject to the rules and regulations established by the University. Toronto thus gives the encouragement to engineering which Mr. Stuart recently urged (see p. 524) should be more liberally given in our own Universities.

THE nineteenth annual report of the Council of the City and Guilds of London Institute, referring to the work of the Institute during the year 1898, has just been issued. A letter sent to the London University Commission by the Institute, and published in the report, is of interest as it states the conditions under which the Institute is willing to accept the position of a School of the University for its Central Technical College. The conditions include the following:—"That, in addition to the Faculty of Science in the reconstituted University, a special separate Faculty of Engineering ought to be created to meet the needs of Schools of the University which are preparing students for a professional career. This Engineering Faculty should have direct representation on the Senate, and should include the subjects of civil engineering, mechanical engineering, electrical engineering, marine engineering, mining engineering, and might possibly also include chemical engineering, metallurgy, architectural construction, and sanitary engineering. The Institute is of opinion that as it appears undesirable, at all events in the first instance, to constitute unduly large faculties, each faculty should consist of the professors alone of the several schools included in the faculty." The Institute has been in-

vited by the Education Sub-Committee of the Royal Commission for the Paris Exhibition of 1900 to co-operate in the work of securing for the exhibition an adequate and comprehensive representation of all grades of educational effort, public and private, in the United Kingdom, and Sir Owen Roberts has been appointed by the Executive Committee to attend the conferences convened by the Chairman, Sir George Kekewich, K.C.B., to consider the arrangements for the educational section.

SCIENTIFIC SERIALS.

American Journal of Science, April.—Glacial Lakes Newberry, Warren, and Dana in Central New York, by H. L. Fairchild. The ice sheet of the last glacial epoch covered all the area of the Great Lakes. When the receding front of the glacier had passed to northward of the southern boundary of the Laurentian basin, the glacial and meteoric waters were impounded between the ice front and the north-sloping land surface. These glacial lakes had their outlets southward across the divide, and they expanded northward as the barrier of ice receded. The author describes the succession of events in the life and extinction of the later and broader glacial waters in the critical district of the Finger Lakes.—Rapid method for the determination of the amount of soluble mineral matter in a soil, by T. H. Means. This method is an electrical one. The sample is treated with distilled water and the specific resistance of the solution is determined. Two men can thus examine from sixty to one hundred samples of soil in a day, and salt maps of irrigated and other districts may be rapidly constructed.—New type of telescope objective specially adapted for spectroscopic use, by C. S. Hastings. The author has constructed an objective consisting of a quadruple combination of silicate flint, borosilicate flint, silicate crown, and barium crown which is absolutely colour-free, and equally adapted to photographic and to eye observations. From the lines A to K, the focal plane for all rays is rigidly the same. There are only two free surfaces, the four lenses being cemented together.—On the phenocrysts of intrusive igneous rocks, by L. V. Pirsson. Not all phenocrysts are intratelluric in the sense that they have been formed at much greater depths than they now occur in. On the contrary, in many cases they have been formed in place, and are of contemporaneous origin with the other constituents of the rocks.—The occurrence, origin, and chemical composition of chromite, by J. H. Pratt. The author has been led to adopt the theory that the chromite occurring in the peridotite rocks of North Carolina was formed at the same time as the peridotite, *i.e.* was held in solution by the molten mass of the peridotite and crystallised out among the first minerals as the mass began to cool.—Two species of Saurocephalus, by O. P. Hay. One of the species described, *S. lanciformis*, is little known. The other species is new. It has a slenderer head and a larger mouth than *S. dentatus*. The author names it *S. pamphagus*.

Correction.—The abstract of G. P. Starkweather's paper, *Am. J. Sc.* for February, should read: The writer adduces evidence from Regnault's own experiments to show that his calorimeter temperatures were reduced to the air thermometer, a fact questioned by Bosscha and others.

Symons's Monthly Meteorological Magazine, April.—Winter minima on British mountain tops. In 1867, the late Mr. H. B. Biden placed a minimum thermometer on the Glyder fach, about four miles E.N.E. of Snowdon, at an altitude of 3262 feet. The thermometer was placed beneath a protecting slab of feldspar porphyry, and left to its fate, being read each spring, and then reset. Mr. W. Piffe Brown has discussed the temperatutes in the *Climbers' Club Journal* for February last. The average for the years 1884–96 except 1894–95, when the record was lost) was 14°·7, the absolute minimum being 8°, in the winter of 1893–94. The accumulation of snow may account for the readings not being lower, but it is improbable that there was always snow there at times of severe cold. At Ben Nevis, the average of the minima for the same period is 7°·5, the absolute minimum being 0°·7 in January 1894. A very contradictory record was obtained by the late Dr. J. F. Miller at Scaw Fell, where the wonderful temperature of −31° was recorded for January and February 1850.—Negretti and Zambra's self-recording rain gauge. Mr. Symons states that this is a very simple and efficient instrument; the rain collected by the receiver falls into the upper half of the vibrating bucket (designed by Sir Christopher Wren). When 0·1 inch of rain has fallen, the bucket tips over and causes a wheel to advance one tooth. Attached to the wheel is a helix on which rests the lever carrying the pen which registers each turnover of the bucket. As the clock (the useful invention of MM. Richard frères) turns the paper about ·001 inch per minute, a very clear curve is produced. The approval of the instrument by Mr. Symons is a guarantee of its usefulness, and the cost is much below some other recording gauges.

THE *Journal of the Royal Microscopical Society* for April contains the President's annual address, which is chiefly devoted to the subject of dispersion; the description of a microscope with new focussing mechanism, by Mr. Keith Lucas; and notes on colour-illumination, with special reference to the choice of suitable colours, by Mr. Julius Rheinberg. Among the notes on microscopy is a contribution to the President's interesting article on the evolution of the microscope, and a description of Powell's iron microscope made in 1838–40. In the same number is a table of the conversion of British and metric measures, computed by Mr. E. M. Nelson from the new coefficient obtained by order of the Board of Trade in 1896.

Wiedemann's Annalen der Physik und Chemie, No. 3.—Behaviour of unpolarisable electrodes towards alternate currents, by E. Warburg. If polarisation is altogether due to the solution of the electrode metal in the liquid and its attendant changes of concentration, the "capacity of polarisation" must be inversely proportional to the square root of the frequency. This applies to the case of silver electrodes in silver nitrate solution, and, to a certain extent, to platinised platinum electrodes in saturated NaCl solution.—Methods of studying slow electric oscillations, by W. König. The author describes several new methods of recording and studying electric oscillations of a frequency comparable with that of ordinary sound-waves. One of these consists in discharging them through a rod provided with a short piece of straw at the end on to a metallic plate covered with asphalt varnish. The sparks produce on the plate something resembling Lichtenberg's figures. The plate is attached to a pendulum, and is drawn across the point. On sprinkling the plate with a mixture of sulphur and red lead a series of red and yellow patches appears, which in connection with the known speed of the pendulum gives the frequency of the sparks. The straw may also be attached to the vibrating prong of a tuning-fork, and so a more direct measurement obtained. The straw is necessary to reduce the intensity of the spark, so as to obtain a sharp line.—A new method of exhibiting electric wire waves, by W. D. Coolidge. The author obtains a glow of the wires of a Lecher wire system at the ventral segments of the stationary waves in the open air by using a Blondlot exciter worked with an induction coil and Tesla transformer, and reducing the thickness of the wire to 0·1 mm.—Alternate-current energy consumed in vacuum tubes, by H. Ebert. Very high frequencies were employed, such as 22,000 oscillations per minute. It was found that at a certain high exhaustion the consumption of energy for a given luminous effect attained a minimum. The pressure at which this takes place is inversely proportional to the mean free path of the gaseous molecules.—Absolute determination of thermal radiation by means of the electric compensating pyrheliometer, by K. Ångström. Of two equal blackened strips of metal, one is exposed to the radiation while the other is brought to the same temperature by means of an electric current. The latter furnishes a measure of the radiation.—Measurement of flame temperatures by means of thermo-couples, by F. Berkenbusch. Two new methods devised by Nernst are tested.—Pressure of saturated water vapour below 0°, by M. Thiesen. The author calculates the vapour pressures over ice and over water respectively down to − 80°.

SOCIETIES AND ACADEMIES.

LONDON.

Physical Society, April 21.—Mr. T. H. Blakesley, Vice-President, in the chair.—A mathematical paper on the effect of a solid conducting sphere in a variable magnetic field on the magnetic induction at a point outside, was read by Mr. C. S. Whitehead. It is an investigation of the magnetic induction at a point outside a solid conducting sphere when magnetic dis-

turbances are taking place in the dielectric envelope. An expression is given for the maximum value of the magnetic induction when the sphere becomes an infinite plate and the inducing system consists of an alternating current in a circular circuit whose plane is parallel to the plate, *i.e.* when the maximum value of the induction tangential to the surface is zero. A second expression gives the maximum value of the magnetic induction normal to the surface for a point at considerable distance from the axis, and just outside the plate. In this latter case, the maximum value of the induction tangential to the surface appears as a function of the maximum current of known frequency in the inducing circuit, the various dimensions in space of the system, and the permeability and specific resistance of the plate. From these equations, taking the most authentic values of the involved constants, the maximum magnetic induction normal to the surface for a sea-water plate is forty-four times as great as it would be for an iron plate, and more than three thousand times as great as it would be for a copper plate. The paper also shows that, for the purpose of induction telegraphy, to get the best effect the receiving coil should have its plane vertical, not horizontal, firstly because the distance of the inducing circuit from the surface of the plate must in practice be small compared with the distance of the point from the axis, so that the maximum normal induction is small compared with the maximum tangential induction; and secondly because the maximum *normal* induction varies inversely as the *fifth* power of the distance of the point from the axis, whereas the maximum tangential induction varies inversely as the fourth power of that distance. In conclusion, Mr. Whitehead applies his formulæ to the practical case mentioned by Prof. Lodge in the *Journal* of the Institute of Electrical Engineers, February 1899, p. 805. Prof. Lodge there describes a horizontal receiving circuit, and states that, with no condensers in the circuit he "was not usually able to hear anything" in the telephone. Mr. Whitehead calculates that under such conditions the theoretical value of the current in Prof. Lodge's horizontal secondary is 0·066 *micro*-amperes, but that with a vertical circuit the received current would have been 33 *milli*-amperes. Mr. Blakesley observed that as a rule experiment preceded theory. He congratulated Mr. Whitehead upon having settled from theoretical considerations that the vertical position of the receiving coil is best. Prof. Everett said that the very elaborate method of analysis adopted in the paper appeared to be very clearly stated. He would like to know whether the inducing coil ought to be vertical as well as the receiving coil. Mr. Appleyard thought that experiment had left no doubt as to the best position of both coils. The early investigations of Mr. Willoughby Smith and the later work of Mr. H. R. Kempe and Mr. Preece had proved that for the best effect both coils should be vertical. But large vertical coils were difficult to fix and expensive to maintain. It was this reason probably that led Prof. Lodge to try what could be done with coils placed horizontally. Mr. Whitehead, in reply, said that his formulæ only applied to a horizontal inducing coil. He had not worked out the case of what would happen if the inducing coil itself was vertical. In the experiments on the Flat Holm both circuits were straight wires with their ends to earth, so that they really amounted to vertical coils.—Mr. R. A. Lehfeldt then gave a demonstration of a method due to Prof. T. W. Richards for standardising thermometers. This depends upon the ordinary latent-heat principle for maintaining constant temperature, but it includes the consideration of generally more than two states or phases of the melting substance. If there are c components and p phases, then the number of degrees of freedom of the system is $[c + 2 - p]$. When this is zero, the temperature and the pressure of the system are perfectly definite. Thus the following chemical formula represents the four phases to be equilibrated in the case of Glauber's salt:

$$\left\{\begin{matrix} Na_2SO_4 10H_2O \\ Na_2SO_4 \\ \text{Solution} \\ \text{Vapour.} \end{matrix}\right.$$

Prof. Richards has determined the temperature of equilibrium in several useful cases. The salts are put into a test-tube in an air-bath formed between it and a second test-tube; the whole is then heated in a beaker of water over a small flame. If the salt is pure, and care is taken to avoid the effect of supersaturation, this method is highly satisfactory. It gives an extensive range of fixed-points, and is especially useful in thermometry for fixed-points between 0° and 100°. A few of these temperatures may be noted:

	°C
Sodium chromate	19·71
Sodium carbonate	53·3
Sodium thiosulphate	48·0
Sodium bromide	50·8
Manganese chloride	57·8
Trisodium phosphate	73·4
Barium hydroxide	78·0

Mr. J. A. Harker asked how long the temperature remained constant. The special value of Richards' method for standardising thermometers of short range had been pointed out by Dr. Chree. It obviated the necessity for auxiliary bulbs, and it would be extremely useful in graduating meteorological thermometers. Mr. Blakesley said that sodium chromate was represented by a very useful temperature. Could this substance be regarded as sufficiently stable to give a satisfactory fixed-point. Mr. Lehfeldt, in reply, said that all the fixed-points mentioned were theoretically as definite as that corresponding to sodium sulphate, but they had not been so accurately determined.

Geological Society, April 12.—W. Whitaker, F.R.S. President, in the chair.—Mr. A. M. Davies, in exhibiting a specimen of glauconitic limestone from the Kimeridge clay, said that it might easily be taken for upper greensand. There are traces of fossils in the stone, but an impression of a *biplex* ammonite was alone recognisable. No similar bed had been previously recorded from the English Kimeridgian.—Fossils in the University Museum, Oxford: (1) Silurian echinoidea and ophiuroidea, by Prof. W. J. Sollas, F.R.S. Attention is called to the correlation of structure and function in the locomotive organs of asterids, ophiurids, and echinids.—Note on the occurrence of sponge-spicules in the carboniferous limestone of Derbyshire, by Prof. W. J. Sollas, F.R.S. Remains of sponge-spicules are fairly abundant in a rock-slice taken from a specimen obtained by Mr. H. H. Arnold-Bemrose from Tissington cutting. They present themselves as sections through long cylindrical rods, but the terminations are obscure and indefinite, and the form cannot be referred with certainty to any recognised order of sponges. The spicules were doubtless originally siliceous, but they are now completely transformed into carbonate of lime.—On spinel and forsterite from the Glenelg limestone, by C. T. Clough and Dr. W. Pollard; communicated by permission of the Director-General of H.M. Geological Survey. The paper opens with an account of previous literature on the subject of minerals in the Glenelg limestone. Neither forsterite nor true spinel has been previously recorded from the limestone or from Scotland at all. The forsterite and spinel are in part associated together in lumps, from which they were separated by means of heavy solutions for analysis. The spinel in hand-specimens is of an almost opaque blue colour, and some examples show small crystal-faces. That seen in microscopic slides is shapeless and colourless, except that the blue portions appear brown by transmitted light. Analyses of the two minerals are given at the close of the paper; and it is pointed out that the spinel is like that of Aker in colour and mode of occurrence.

Mineralogical Society, April 11.—Mr. R. H. Scott, Past-President, in the chair.—Mr. F. R. Mallet gave the results of the examination of a mineral obtained many years ago from the Mayo salt mines, Punjab; he proves it to be Langbeinite, sulphate of potassium and magnesium ($K_2SO_4.2MgSO_4$), a species first established in 1891 from material found in the Prussian salt deposits.—Mr. L. Fletcher gave an account of a mass of meteoric iron from Patagonia, a fragment of which had been brought to this country by Dr. F. P. Moreno of La Plata; the material contains nearly 10 per cent. of nickel and cobalt, and belongs to the class of octahedral meteoric irons, like that of Toluca.—Mr. G. F. H. Smith read a paper on the use and advantages of a three-circle goniometer. The older form of goniometer with one circle has the grave disadvantage that the crystal must be re-adjusted for different zones. In the case of the theodolite goniometer with two circles, the crystal is adjusted once for all, and measurements are made of the polar distance and azimuthal angle of each face; but by this method no use can be made of the law known as the anharmonic ratio of four poles in a zone, and in fact the indices of faces are not readily determin-

able. By adding a third circle, the advantages of both methods may be combined. The crystal is adjusted once for all, and measurements may be made in any zone at will. One circle gives the angle in this zone, the second the angle this zone makes with a fixed zone, and the third the pole in which this zone intersects the fixed zone. A short description was given of the apparatus necessary to convert an ordinary goniometer into the three-circle form, which is now under construction by Messrs. Troughton and Simms.

Royal Meteorological Society, April 19.—Mr. F. C. Bayard, President, in the chair.—Mr. H. Mellish read a paper on soil temperature, in which he discussed the observations from the thermometers at various depths in the soil which have been made at the stations of the Royal Meteorological Society. These records have been carried on at many of the stations since 1881, and observations have been made at the following depths in the soil: 3 inches, 6 inches, 1 foot, 2 feet, and 4 feet. It appears that in nearly all cases the annual temperature of the soil at the depth of 1 foot is slightly higher than that of the air. In winter time the air and the soil at 1 foot have about the same temperature, the soil being often a little warmer till about the end of January, after which, for the next two months, the air has a small advantage; but in the summer months the soil at 1 foot is generally warmer than the air, the difference exceeding 3° at several stations. Mr. Mellish shows that on the mean for the year the light soils are 1°·0 warmer than the air, while the strong ones are only 0°·2 warmer; and he is of opinion that near the surface we may expect to find wider extremes of temperature in light soils than in strong ones; but that the heavier soils are better conductors of heat, and that consequently the extremes are propagated to greater depths in heavy soils than in light ones.—A paper on some phenomena connected with the vertical circulation of our atmosphere, by Major-General H. Schaw, C.B., R.E., was read by the Secretary. The author has for some time past been studying the circulation of the atmosphere over Australasia, and in this paper gives the results of his examination of the weather charts, chiefly in regard to the interaction of cyclones and anticyclones upon each other.

PARIS.

Academy of Sciences, April 17.—M. van Tieghem in the chair.—On the transformation of surfaces of total constant curvature, by M. Gaston Darboux.—New researches on the heats of formation and combustion of several nitrogen compounds, by MM. Berthelot and G. André. Determinations are given for cholesterine, glycollic and lactic nitriles, xanthine, paraphenylene-diamine, nicotine, pyrrol, carbazol, indol, scatol, oxindol, and α-methylindole.—On the applications of aluminium, by M. A. Ditte. A reply to some observations of M. Moissan on the same subject.—Remarks by M. Berthelot on his work "Animal Heat."—Observations on the planet E L Coggia made at the Observatory of Toulouse with the Brunner equatorial of 23 cm. aperture, by M. F. Rossard.—On some ancient showers of shooting-stars, by M. D. Eginitis.—On the periodic integrals of linear partial differential equations of the first order, by M. Levi-Civita.—Extension of the theorem of the mean to differential equations of the first order, by M. Michel Petrovitch.—On the theory of fundamental functions, by M. W. Stekloff.—Improvements in the electrolytic interrupter of Wehnelt, by M. J. Carpentier. By carefully insulating thermally the electrolytic cell, the temperature is allowed to rise from 80° to 100° C.; as the temperature rises, a smaller voltage is required in the primary circuit. If the length of platinum wire exposed is capable of adjustment, more control is obtained over the working of the coil.—Contribution to the study of the Wehnelt interrupter, by M. H. Armagnat.—On the decomposition of a high potential current into a series of disruptive discharges, by M. H. Abraham.—A cathodic rectifier for induced currents, by M. P. Villard. A Crookes' tube has one bulb of 400 cc. capacity, carrying a large wire spiral as electrode, the other electrode being very small, a few millimetres only in diameter, placed in a narrow tube which is slightly contracted just in front of the disc. This tube, when connected to an induction coil round the primary of which an alternating current is passing, allows only one alternation of the two induced currents to pass, thus acting as a rectifier.—On silver suboxide, by M. Guntz. When Ag_2O is heated in a strong sealed tube at 358°, there is a certain equilibrium (about 49 atmospheres) corresponding to the dissociation tension of Ag_4O. That this pressure corresponds to the suboxide was shown by the following experiment. Into a glass tube of known volume is placed sufficient $KMnO_4$ to give off at 358° oxygen at a pressure just above 50 atmospheres, and two glass tubes containing known weights of silver and silver oxide respectively; and the whole is heated for three days to 358° C. Analysis of the products showed that the Ag_2O had lost weight and the silver had gained weight, and that the gain and loss corresponded exactly in both cases to the formation of Ag_4O.—On the solubility of the normal acids of the oxalic series in water, by M. F. Lamouroux. The acids of the oxalic series, both of odd and even numbers of carbon atoms, are in general slightly soluble in water, the only exceptions being malonic and glutaric acids, which are very soluble.—On the solubility in water of the substituted malonic acids, by MM. G. Massol and F. Lamouroux. Various mono- and di- substituted malonic acids were examined up to acids containing eight atoms of carbon, but no regularities could be deduced.—Action of ethyl, isobutyl, and isoamyl alcohols upon their sodium derivatives, by M. Guerbet. By heating pure inactive amyl alcohol at 150°–160° with its sodium derivative, a new alcohol, diamyl alcohol, $C_{10}H_{22}O$ was obtained, from which various derivatives were obtained, including the chloride, acetate, isovalerate, and benzoate. Bisulphate of potassium gave a hydrocarbon $C_{10}H_{20}$, and oxidation with chromic acid a new acid $C_{10}H_{20}O_2$. Ethyl alcohol studied in a similar fashion, gave at 210° hydrogen and ethylene, but no product corresponding to the diamyl alcohol.—Action of very dilute acids upon the phosphates of the soil, by M. Th. Schlœsing, jun.—On a simple measuring apparatus for use in stereoscopy, the stereometer, by MM. T. Marie and H. Ribaut.—General considerations on the defensive glands in the Coleoptera, by M. L. Bordas.—On the Trias of the neighbourhood of Rougiers (Var), and on the existence in this region of phenomena analogous to the peperites of Auvergne, by M. J. Repelin.—On the origin of the siliceous and quartose grains found in chalk, by M. Stanislas Meunier.

AMSTERDAM.

Royal Academy of Sciences, February 24.—Prof. Van de Sande Bakhuyzen in the chair.—Prof. Schoute reported, in the name of Prof. Korteweg and himself, upon a paper of Mr. S. L. van Oss, entitled "Das regelmässige Sechshundertzell und seine sellstdeckenden Bewegungen." The paper will be published in the Academy's *Transactions*.—Prof. Jan de Vries, on orthoptic circles belonging to linear systems of conic sections.—Prof. Bakhuis Roozeboom, on solubility and melting point as criteria for the distinction of racemic compounds, partially racemic compounds, pseudoracemic mixture crystals and inactive conglomerates.—Prof. Schoute, on a geometric interpretation of the generalisation of Sylvester's catalecticant.—The above three communications will be inserted in the report of the meeting.—Prof. Haga made, both on behalf of himself and Dr. C. H. Wind, a communication on the diffraction of Röntgen rays. Diffraction of X-rays was proved by an experiment arranged as follows: The Röntgen-tube was placed behind a slit 1 c.m. high and 14 microns wide, at 75 c.m. from the latter was the diffraction slit, which gradually diminished in width from 17 to about 2 microns. The photographic plate was placed at 75 c.m. from the diffraction slit. Time of exposure from 100 to 200 hours. The image of the slit first became narrower, and then showed an unmistakable broadening. From the width of the part of the diffraction slit, corresponding to this broadening and the character of the broadening, an estimation can be made of the wave-length. It appeared that X-rays exist of about 0·1 to 2½ Ångström-units, comprising four octaves.—A detailed paper will appear in the report of the next meeting.—Prof. Stokvis presented for publication in the *Proceedings* a short account of experiments, made by Dr. G. Bellaar Spruyt in his laboratory, on the physiological action of methylnitramine. From these experiments it appears that the nitramines show no nitrite actions whatever in the animal organism, and that, consequently, as homologous chemical structure necessarily brings with it homologous physiological action, in accordance with Franchimont's view, they must be considered substances in which nitrogen is most probably cyclically combined.—The following papers were presented for publication in the *Proceedings*:—Two communications by Prof. Lorentz (*a*) on a simplified theory of the electrical and optical phenomena in moving bodies (*b*) Stokes's aberration theory presupposing an ether of unequal density. Two communications by Dr. J. Verschaffelt, presented by Prof. Kamerlingh Onnes, and entitled (*a*) measurements on

the course of the isotherms in the proximity of the plait point, and specially on the course of the retrograde condensation in the case of a mixture of carbonic acid and hydrogen (continuation); and (*b*) measurements on the variations of pressure on one component, being substituted for another in mixtures of carbonic acid and hydrogen. A paper by Dr. Ernst Cohen, presented by Prof. Bakhuis Roozeboom, and entitled, "On electrical reaction velocity." A communication by Prof. Franchimont, concerning the dissertation of Mr. L. T. C. Schey, presented to the library of the Academy, and entitled "On neutral glycerine esters (triacylines) from saturated monobasic acids with an even number of C-atoms." The dissertation gives an account of the preparation of the following substances, all of which were obtained by heating the acid with glycerine in a space filled with rarified air, and with a slight current of air:—Tributyrine, tricaproine, tricapryline, tricaprine, trilaurine, trimyristine, tripalmitine, and tristearine. The first three are liquids, the others solids. The density, the index of refraction, and the melting-point of each of them, were determined. The melting-point of tricaprine is the same as that of caprine acid; the melting-points of the lower terms of the acylines are below those of the corresponding acids, those of the higher terms are higher.—This work will be published in the "Recueil des Travaux chimiques des Pays-Bas et de la Belgique."

DIARY OF SOCIETIES.

THURSDAY, APRIL 27.

ROYAL SOCIETY, at 4.30.—Data for the Problem of Evolution in Man. I. A First Study of the Variability and Correlation of the Hand: Miss Whiteley and Prof. Karl Pearson, F.R.S.—The Luminosity of the Rare Earths when Heated *in vacuo* by means of Cathode Rays: A. A. C. Swinton.—On a Quartz Thread Gravity Balance: R. Threlfall and J. A. Pollock.—On the Electrical Conductivity of Flames containing Salt Vapours: H. A. Wilson.—On a Self-recovering Coherer and the Study of the Cohering Action of Different Metals: Prof. J. C. Bose.—On the Presence of Oxygen in the Atmospheres of certain Fixed Stars: Dr. Gill, F.R.S.

ROYAL INSTITUTION, at 3.—The Atmosphere Prof. J. Dewar, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Experiments on Alternate Current Arcs by Aid of Oscillographs: W. Duddell and E. W. Marchant. (Conclusion of Discussion.)—Capacity Measurements of Long Submarine Cables: J. Elton Young.

INSTITUTION OF MECHANICAL ENGINEERS, at 7.30.—Address by the President, Sir William H. White, K.C.B., F.R.S.

FRIDAY, APRIL 28.

ROYAL INSTITUTION, at 9.—Some Features of the Electric Induction Motor: Prof. C. A. Carus Wilson.

INSTITUTION OF MECHANICAL ENGINEERS, at 7.30.—Evaporative Condensers: Harry G. V. Oldham.

MONDAY, MAY 1.

SOCIETY OF ARTS, at 8.—Leather Manufacture: Prof. H. R. Proctor.

VICTORIA INSTITUTE, at 4.30.—Nationality: Prof. T. McK. Hughes, F.R.S.

TUESDAY, MAY 2.

ROYAL INSTITUTION, at 3.—Electric Eddy-Currents: Prof. S. P. Thompson, F.R.S.

ZOOLOGICAL SOCIETY, at 8.30.—Sur le Type Primitif des Molaires Plexodontes des Mammifères: Dr. F. Ameghino.—Notes on Chinese Mammals, principally from the Western Province of Sechuen: W. E. de Winton.—On a Collection of Land-Shells from British Central Africa: Edgar A. Smith.

WEDNESDAY, MAY 3.

SOCIETY OF ARTS, at 8.—Ætheric Telegraphy: W. H. Preece, C.B., F.R.S.

SOCIETY OF PUBLIC ANALYSTS, at 8.—On some Comparative Analyses of, and Digestive Experiments with White and Whole Meal Breads: Dr. Otto Rosenheim and Dr. Phillip Schidrowitz.—The Assay of Belladonna, B.P.: F. C. J. Bird.—On the Use of Boric Acid and Formaldehyde as Milk Preservatives: Dr. S. Rideal and G. R. Foulerton.—The Value of the Estimation of Pentosans in Food Materials: Otto Hehner and W. P. Skertchly.

ENTOMOLOGICAL SOCIETY, at 8.

THURSDAY, MAY 4.

ROYAL SOCIETY, at 4.30.—*Onygena equina* (Willd.): a Horn-destroying Fungus: Prof. Marshall Ward, F.R.S.—Impact with a Liquid Surface studied by the Aid of Instantaneous Photography. Paper II.: Prof. Worthington, F.R.S., and R. C. Cole.—The External Features in the Development of *Lepidosiren paradoxa* (Fitz.): J. G. Kerr.—An Observation on Inheritance in Parthenogenesis: Dr. E. Warren.—The Thermal Expansion of Pure Nickel and Cobalt: A. E. Tutton.

LINNEAN SOCIETY, at 8.—The Position of Anomalurus as indicated by its Myology: F. G. Parsons.—On *Notheia anomala*, Harv. et Bail.: Miss Ethel S. Barton.—On Variation in the Desmidiæ: G. S. West.

CHEMICAL SOCIETY, at 8.—On the Combustion of Carbon Disulphide: H. B. Dixon and F. J. Russell.—The Action of Nitric Oxide on Nitrogen Peroxide: H. B. Dixon and J. D. Peterkin.—On the Mode of Burning of Carbon: H. B. Dixon.—Crystalline Glycollic Aldehyde: Henry J. Horstman Fenton and Henry Jackson.—On the Blue Salt of Fehling's Solution and other Cupro-tartrates: Orme Masson and B. D. Steele.—The Preparation of Acid Phenolic Salts of Dibasic Acids: Dr. S. B. Schryver.—The Maximum Pressure of Napthalene Vapour: R. W. Allen.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Electric Locomotives in Practice and Tractive Resistance in Tunnels, with Notes on Electric Locomotive Design: G. V. McMahon.

FRIDAY, MAY 5.

ROYAL INSTITUTION, at 9.—Pictures produced on Photographic Plates in the Dark: Dr. W. J. Russell, F.R.S.

GEOLOGISTS' ASSOCIATION, at 8.—The Drainage of Cuestas: Prof. W. M. Davis.

SATURDAY, MAY 6.

GEOLOGISTS' ASSOCIATION.—Excursion to the Thame District. Director: A. M. Davies. Leave Paddington at 9.50.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—Statesman's Year-Book, 1899 (Macmillan).—The Arithmetic of Chemistry: Dr. J. Waddell (Macmillan).—How to Know the Ferns: F. T. Parsons (New York, Scribner).—Premiers Principes d'Electricité Industrielle: P. Janet, trois. édition (Paris, Gauthier-Villars).—Royal University of Ireland, Calendar, 1899 (Dublin, Thom).—The Spirit of Organic Chemistry: Prof. A. Lachman (Macmillan).—A Course of Practical Chemistry: M. M. P. Muir, Part 2 (Longmans).—Plato and Darwin: The Abbé M. Hébert, translated by Hon. W. Gibson (Longmans).—Cape of Good Hope, Department of Agriculture, Annual Report of the Geological Commission, 1897 (Cape Town).

PAMPHLETS.—Field Columbian Museum, Annual Report, 1897–98 (Chicago).—Tre Nebulose fotografate recentemente alla Specola Vaticana: P. G. Lais (Roma).

SERIALS.—Scientia, Nos. 1 to 3 (Paris, Carré).—Journal of the Franklin Institute, April (Philadelphia)—Zoologist, April (West).—Journal of Anatomy and Physiology, April (Griffin).—Bulletin de la Classe des Sciences, 1899, Nos. 1 and 2 (Bruxelles).—Journal of the Institution of Electrical Engineers, April (Spon).—Among British Birds in their Nesting Haunts: O. A. J. Lee, Part xiv. (Edinburgh, Douglas).—Journal of the Sanitary Institute, April (London).—Jahrbuch der K. K. Geologischen Reichsanstalt, xlviii. Band, 2 Heft (Wien).—Quarterly Review, April (Murray).—Journal of the Chemical Society, April (Gurney).

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