THURSDAY, FEBRUARY 4, 1892.

CARPENTER BY DALLINGER.

The Microscope and its Revelations. By the late William B. Carpenter, C.B. M.D., F.R.S. Seventh Edition, by the Rev. W. H. Dallinger, LL.D., F.R.S. (London: J. and A. Churchill, 1891.)

THE earlier editions of Dr. Carpenter's "Microscope" had a satisfactory basis. They formed an excellent guide to the use of the instrument, in days when microscopic *technique* was far less elaborated than it is now, written by an enthusiastic and experienced worker. Dr. Carpenter told us about the theory of the microscope and the different kinds of stages, rack-works, and objectives which he himself had seen and tried; and then gave a somewhat casual and purely personal account of different animal, vegetable, and mineral structures which had been investigated with the microscope, and had especially excited his interest and attention. The book was valuable because it contained the advice and judgment of a great authority, and original observations upon a heterogeneous assemblage of objects by a highly competent naturalist. The later editions of the book, even in Dr. Carpenter's hands, lost a good deal of the original character of the work. New matter of all kinds was fitted in, until the volume became very bulky. Still, the selection of material was made by one man, and the work might be regarded as his note-book, his conception of what was most interesting and instructive in the wide field of microscopic research. An edition of such a book by other hands after the death of the original author is not likely to be a real success, though it may justify a publisher's commercial foresight. Dr. Carpenter's name is a good one to trade with; but as a matter of fact there is not much of Dr. Carpenter in the present work, and what there is has only impeded the naturalists who have assisted Dr. Dallinger in elaborating its contents. The result is very confusing: the reader often is at a loss to know whether a statement is one surviving from Dr. Carpenter himself or is introduced by the new editor.

The book really consists of five treatises compressed into a single volume, no one of which excepting the first is by any means complete. These treatises are: (1) on the theory of microscopical optics, and the history and present development of the compound microscope and accessory instruments; (2) on microscopic *technique*; (3) on the vegetable kingdom and vegetable histology; (4) on the animal kingdom and animal histology; (5) on the microscopic structure of minerals and rocks.

The first of these treatises is a new and original work by Dr. Dallinger, and occupies five chapters. It contains a valuable exposition of the theory of modern objectives, and some interesting records of ancient microscopes. The statements on p. 209, as to the introduction of the Hartnack model and objectives into this country, and the motives which led to it, are entirely erroneous. I had a large share in that innovation; and I have no hesitation in stating that what led to the importation of German and French microscopes direct from their makers was the simple fact that one obtained an efficient instrument for about one-fourth of the price exacted at that time by English makers for an instrument of no greater practical value; whilst it was also the fact that English dealers (not the great makers) were in the habit of selling inferior Continental objectives (rejected by their makers) as their own "make," at higher prices than would suffice to purchase first-rate glasses from the Continental firms. The result of the diversion of English purchasers to Continental stands and objectives was the simplification of English models, and an enormous reduction in the price of English-made objectives.

The treatise on section-cutting, mounting, use of reagents, &c., is necessarily short, and lacks that completeness and authority which can alone make a laboratory guide really useful. But the chapter on practical microscopy is a really valuable one, giving the matured conclusions of the editor as to the true methods of getting the best possible performance from the instrument. The English school of microscopists is unrivalled in the services which it has rendered to the development of the microscope as an instrument of precision, and in the cultivation of the art of obtaining from it the most perfect optical results by skilful management of illumination, &c., as also of rightly judging and correcting those results. The high eulogy passed on the Royal Microscopical Society (p. 340), in view of its services in this field, is amply warranted. It is, however, to be regretted that the name of the late Dr. Royston Pigott, F.R.S., is omitted from the history here given of the improvements in condensers, objectives, and eye-pieces. His valuable contributions to the subject were rejected by the Society in 1870, and published in the *Quarterly Journal of Microscopical Science* at that period.

The last three treatises are what give the book its strange and almost incomprehensible character. There can be no doubt that Prof. Bell would have written an excellent original treatise on microscopic animals, and Mr. Bennett an equally valuable one on microscopic plants; but they have not been asked to do this. They and others, and the editor himself, have contributed fragments which are mixed up with fragments of the original Carpenter in inextricable confusion.

The "Author," with his capital A, appears as of old, but he will now receive credit for opinions he never held, and would probably have rejected. The present editor is, however, careful to take responsibility himself for a very remarkable statement—namely, that the saprophytic Monadinæ (such as *Monas Dallingeri* of Sav. Kent and others)

> "possess features that ally them to the vegetable series, and indicate affinities with certain Nostocaceæ and the Bacteria; while a leaning to the Mycetozoa [already classed by our editor among Fungi!] and the chlorophyllaceous Algæ, and even some forms of Fungi, is quite apparent to the careful student."

It is somewhat startling at the present day to come across conceptions of this kind—groups "leaning" this way and that, with remote affinities to half-a-dozen incompatible ancestries. One would like to know in plain English whether Dr. Dallinger considers that the Monadinæ have descended from Nostocaceæ, or from Mycetozoa, or from green Algæ, or any of the latter from any of the former, or all from a common ancestor; and what grounds he has for his view as to their genealogy.

Many of the old topics enlarged upon by Carpenter are treated with increased amplitude in the present edition. Excellent plates (some of them coloured) illustrate the Desmids, the Diatoms (the old *crux* of the sculpturing of the valves is more than ever to the fore), the Monads, the Rotifers, and the Foraminifera. Three coloured plates of the structure of Acari are introduced; they are very interesting, but surely out of proportion in a work on the microscope where no adequate illustrations of the Ciliate Infusoria are given, and where the account of the phenomena of conjugation in that class is far from being up to date both as to statement and illustration.

I do not wish to speak unkindly of an old friend, even when rigged out in such a strangely variegated new set of clothes as are those furnished to "The Microscope" in its seventh edition. There is a great deal of very interesting matter; there are numbers of excellent woodcuts and plates in the book, some old and a great many new—one thousand in all. The defect of all the earlier editions remains in the present—namely, that whilst you may find several pages, plates, and figures about one subject connected with microscopy, you will find only three lines or nothing at all about another. So long as Dr. Carpenter wrote successive additions to the book, one understood why some subjects should be treated fully and others passed over, and at any rate one knew who was responsible for any statement or omission. Now the book has (so far as its second half is concerned) lost its authoritative character, and is more than ever a patchwork of paragraphs on arbitrarily selected subjects, the responsibility for which is divided in some mysterious way between the editor (who, of course, does not claim to be another Carpenter), and certain Fellows of the Royal Microscopical Society.

I should wish, on the other hand, to express the opinion that the first half of the book (which alone really deals with the microscope and the art of microscopy, and is not by Dr. Carpenter, but entirely new—by Dr. Dallinger) is a work of high scientific value—by far the best on the subject—and one which every worker with the microscope should thoroughly study and take to heart.

E. RAY LANKESTER.

ELEMENTARY THERMODYNAMICS.

Elementary Thermodynamics. By J. Parker, M.A. (Cambridge: University Press, 1891.)

IN a six-lined note, which does duty as preface, the author of "Elementary Thermodynamics" tells the beginner what to omit. From a beginner's stand-point the book must therefore be judged. A first glance will probably startle the reader into exclaiming, What can Kepler's laws have to do with Carnot's principle? Fortunately, however, the sections containing Kepler's laws, and much other apparently irrelevant matter, are those the beginner is advised not to read. With the mere remark that all this is preliminary to an elementary exposition of Darwin's calculations in tidal friction, it will best serve all purposes to confine the attention strictly to things thermodynamic. The most important chapters, alike from the teacher's and pupil's points of view, are the first and third, dealing with the foundations of the science.

The first chapter is headed "The Conservation of Energy." It develops in mathematical form the general differential equation of energy, but is lamentably feeble in the physical or experimental side. True, there is a brief discussion of some of Joule's experiments; but we venture to think it would require a greater than Joule to find that a calorie was equivalent to 41,539,759·8 ergs! A little further on, the latent heat of ice under a pressure of one atmosphere is given as 79·25 calories, or 3,292,025,964 ergs!! Surely it "was the most unkindest cut of all" thus to spurn the 0·15. The truth taught here is, that ten-place logarithms do bare justice to "Parkerian" reductions.

A novelty of treatment is the division of forces into *contact-forces* and *ether-forces*. To Prof. Lodge is ascribed the doubtful honour of having suggested this treatment. Contact-forces, we are told, exist between particles in contact; while "the principal ether-forces in Nature which do work, in addition to gravitation and radiation forces, are those which give rise to chemical, physical, electric, and magnetic actions." It is not easy to see the exact meaning of the word "physical" in this definition. If it includes elasticity, cohesion, adhesion, and capillarity, why should pressure, impact, and frictional effects be excluded? Is there, indeed, any evidence of the existence of contact-forces (in Mr. Parker's sense) between *particles?* To our gross senses, visible masses seem to get into contact with each other; but, when once we introduce an ether as the *vera causa* of all actions between bodies not in apparent contact, we are compelled to regard this ether as an ocean in which matter is an archipelago of particles or a swarm of maelstroms. How, then, can "contact-forces" exist at all, since ether must intervene between particle and particle? In any case an elementary text-book is hardly the place to introduce crude ethereal speculations.

Chapter iii. is devoted to "Carnot's Principle," and these two most significant words form head-lines to 136 pages of a book that just tops the 400. This is good. Nevertheless, the "principle" itself, so far as we can discover, is never once explicitly stated. The chapter opens with a brief historic sketch, in which we are told that Clapeyron brought Carnot's work "prominently" forward in 1834. Yet it was not till fourteen or fifteen years later that Thomson discovered to the scientific world the greatness of Carnot, and clearly pointed out the necessity for modifying Carnot's reasoning so as to bring it into accord with the true theory of heat. From Thomson's second paper (1849) Clausius dates his inspiration. Of all this Mr. Parker says nothing, nor does he seem to be aware that Thomson, two years before Clausius and Rankine published anything, pointed out how Carnot's principle led to the conception of an absolute scale of temperature. Moreover, there can be no question that Thomson first gave an unexceptionable enunciation of the "axiom" underlying Carnot's principle. Such particulars are probably of no interest to an author who defines "the very important axiom . . . substantially due to Carnot" in language which may be thus paraphrased: No mechanical work can be gained from a cycle of operations imposed upon a system in thermal communication with two bodies only which are at the same temperature. As a basis for the second law, is not this like Samson shorn of his locks?

But in the really important demonstrations Mr. Parker uses, as a logical equivalent of this, an axiom which again is nowhere given explicitly, but may be thus enunciated: During a complete cycle, in which the working substance is in thermal communication with two bodies each at a constant and uniform temperature, it is impossible for a positive quantity of heat to be absorbed from the one and no heat whatever to be exchanged with the other body. The general truth of this "axiom" will be admitted rather because it agrees with Carnot's principle than because of any inherent merit it may itself possess. An axiom must appeal to experience at bottom; and if one had striven to evolve the said axiom in the most unaxiomatic guise attainable, one could hardly have succeeded better. Sad, indeed, *his* lot whose introduction to Carnot's principle is through such tortuous paths!

But the impression gathered from a careful consideration of Section 49 is that the second implied form must be regarded as simply another statement of the first implied form of "Carnot's axiom." Take, for example, the following argument:—

"The quantities of heat absorbed by the system from the two bodies A, B [each at a constant and uniform temperature] during any complete cycle cannot both be positive. For we could then, by expending work in friction, cause the system to undergo a cycle of operations in which a positive quantity of heat was absorbed from one of the bodies A, B, and no heat at all received from or parted with to the other. In other words, we should be able to take heat from a body whose temperature was uniform and constant, and transform it into work without the presence of any other body of different temperature, contrary to Carnot's axiom."

Little good would be served by criticizing these statements at length, which seem to contain at least as many assumptions as sentences. It would be interesting to know what becomes of the work spent in friction, so arbitrarily introduced, and so cunningly disregarded. After all, however, although the second implied form of "Carnot's axiom" may be generally true, it certainly is not so in the particular case in which the one body is at absolute zero. This is quite as conceivable a contingency as the realization of the assumed thermal conditions of the bodies A and B.

After having, by a perfect volley of *reductiones ad absurdum*, reduced all reversible cycles, working between the same temperatures, to the same efficiency, Mr. Parker introduces Thomson's absolute scale of temperature in the usual form $\frac{q_a}{q_b} = \frac{\theta_a}{\theta_b}$. Then should come (since it has not come earlier) the proof that the reversible cycle has more efficiency than any other conceivable cycle. But all we find is this sentence:—

"It will be easily seen that, if the irreversible cycle be non-frictional, q_a/q_b will be equal to θ_a/θ, and that in all other cases it will be less."

"It will be easily seen" is easily said, and throws the burden of the proof upon the intelligence of the learner—the proof of what is the kernel of the whole of thermodynamics. And *this* is teaching!

We are firmly convinced that after reading this third chapter the average student will have the haziest ideas of what reversibility means, will be utterly at a loss to know what Carnot's principle really is, and will look upon the "conception of entropy" as a phrase to conjure by. It is with decided feelings of relief that we pass on to chapter iv., "Applications of Carnot's Principle." It may be well to remark here that chapter ii., "On Perfect Gases," discusses the simpler thermodynamic properties of the ideal gas obeying Boyle's and Charles's laws. The experimental truth established by Joule, that the heat absorbed by such a gas is equal to the work done by it during the expansion, is made the basis of the whole inquiry. In both these chapters the ground covered is familiar. For example, Thomson and Joule's experimental determination of the absolute zero of temperature is given with commendable fullness. Critical points, latent heats of saturated vapour, and certain aspects of solution and capillarity are all treated in due order, and with sufficient fullness of numerical detail to make them thoroughly intelligible. In the fifth and sixth chapters, again, we are introduced to the thermodynamic potential. We are not aware that the general energy methods of Massieu and Helmholtz have ever before been presented in connected form to English readers. This Mr. Parker has done, and has deservedly earned our tribute of praise. Anyone who is familiar only with the earlier methods by which the founders of the modern theory grappled with the subject, will find these two last chapters, and especially chapter vi., particularly interesting.

The author is not, however, to our mind so happy in his account of Gibbs's thermodynamic surface as, from the tenor of his introductory remarks, we had expected him to be. After animadverting upon "the very brief notice in Maxwell's 'Theory of Heat'" of "this beautiful geometrical construction . . . which does not seem to have obtained the attention it appears to deserve," Mr. Parker proceeds presumably to give it this attention. But what do we find? Five pages of not very lucid description as against Maxwell's eleven and a half. Perhaps, however, this is of small consequence; for, beautiful though it be as a bit of geometry, the thermodynamic surface, even in concrete form, is of doubtful efficiency in the presentation of thermodynamic truth.

Mr. Parker's book possesses not a few merits, but is marred as an educational work by many faults, chief among which is the tangled presentation of the second law. It is hard, indeed, to get up much enthusiasm for an author who speaks of the *speed* at which a body cools, who casts a slur upon British meteorology by declaring that the Centigrade is "the only thermometer now used for scientific purposes," and who gives no less than three distinct and irreconcilable estimates of the sun's radiation in as many consecutive pages. The loosely expressed but familiar axiom that "heat cannot flow of itself" up a temperature grade is referred to as an important *consequence* of Thomson's definition of absolute temperature; and of the Maxwell "Demon," and all that therein is, there is not even the suggestion of a hint.

The book ends with an appendix of physical constants compiled from various sources. Otherwise, its usefulness is sadly diminished by lack of an index or even table of contents.

C. G. K.

THE CENTURY DICTIONARY.

The Century Dictionary: an Encyclopædic Lexicon of the English Language. Prepared under the superintendence of William Dwight Whitney, Ph.D., LL.D. In Six Vols. (New York: The Century Co. London: T. Fisher-Unwin.)

THE preparation of an English dictionary on the scale of the present work is a task of enormous difficulty, and Prof. Whitney may be cordially congratulated on the success with which, in association with numerous collaborators, he has accomplished it. In the course of his labours he kept before himself three objects: the construction of a dictionary which might be consulted with advantage for every literary and practical use; a collection of the technical terms of the various sciences, arts, trades, and professions, more nearly complete than any that had ever before been attempted; and the presentation, along with the definitions proper, of such encyclopædic matter, with pictorial illustrations, as should render the work a convenient book of general reference.

One result of this far-reaching plan is that the number of words included is very much larger than the vocabulary of any preceding dictionary, about 200,000 words having been defined. It is impossible, even in such a dictionary as this, to give every word or form of a word that may at some time have been used by an English writer or speaker; but the editor, as a rule, has very properly preferred to err on the side of "broad inclusiveness" rather than on that of "narrow exclusiveness." He has sought to make the work "a practically complete record of the main body of English speech, from the time of the mingling of the Old French and Anglo-Saxon to the present day, with such of its offshoots as possess historical, etymological, literary, scientific, or practical value." A good deal of space has therefore necessarily been given to obsolete words and forms, the inclusion of which will have the warmest approval of all who desire to promote the study, on scientific principles, of the evolution of the English language. An unusual number of "dialectal" and provincial words have also been admitted, and, as was to be expected in the case of a work compiled in the United States, much attention has been given to "Americanisms," some of which are merely survivals of older or provincial English, while others have been generally adopted on this side of the Atlantic. Another cause of increase has been the admission of an immense number of words which have come into existence during the present century through the progress of knowledge and labour, scientific, artistic, professional, mechanical, and practical. Liberal as the editor has been in this direction, no one who uses the dictionary is likely to think that his liberality has been excessive.

It is scarcely necessary to say that the utmost care has been taken with the etymological part of the work. In explaining what has been done in this department, the editor does not express himself happily when he speaks of "the making of the English language" as having begun "with the introduction of Roman rule and Roman speech among the barbarous Celts of Britain." If there is any intelligible sense in which we can talk of the English language as having "begun," we must surely trace its beginning to the formation of the Low Dutch dialect or dialects from which the most vitally essential elements of our present speech are directly descended. The fact, however, which Prof. Whitney desires to emphasize is that the vocabulary of our language has sprung from various sources, and that for a proper understanding of its characteristic qualities the study of its etymology is on this account of extreme importance. The current accepted form or spelling having been presented, each important word is traced back through earlier forms to its remotest known origin. In revising the proofs of those portions of the work which deal with A and part of B, the authors had the great advantage of being able to consult Dr. J. A. H. Murray's masterly "New English Dictionary on Historical Principles"; and they also express acknowledgments to other writers. The work however, gives ample evidence of independent research; and Prof. Whitney claims that "it has been possible, by means of the fresh material at the disposal of the etymologist, to clear up in many cases doubts or difficulties hitherto resting upon the history of particular words, to decide definitely in favour of one of several suggested etymologies, to discard numerous current errors, and to give for the first time the history of many words of which the etymologies were previously unknown or erroneously stated."

With regard to orthography, we may note that in cases in which English usage and American usage are not identical (as in words like "labour," "traveller," "theatre") both forms are given; a plan with which neither Americans nor Englishmen can reasonably find fault. In the definition of words, the object has been to separate more or less sharply those senses of each word which are really distinct, while over-refinement of analysis has been avoided. As far as possible, the definitions have been arranged historically; and they are illustrated by a very large collection of extracts representing all branches and periods of English literature. Here we are interested mainly in the definitions of scientific terms; and, speaking of these generally, we can say that they are remarkable both for accuracy and for conciseness. Some slips were, of course, inevitable. "Achronical" (given as "acronychal") is thus defined:—"In *astron.*, occurring at sunset: as, the *acronychal* rising or setting of a star: opposed to *cosmical*." This is very misleading, the real meaning being, as we recently had occasion to explain, that in achronical rising and setting "we have the star rising when the sun is setting, and setting when the sun is rising." But, upon the whole, it is most creditable that work over so vast a field, and presenting so many difficulties, has been so efficiently done. On this account alone, even if the dictionary had nothing else to recommend it, it would be of great service both to men of science and to the public.

In the encyclopædic portion of the work, the "Century Dictionary" cannot, of course, be compared with any of the great Encyclopædias. Still, skilful management has enabled the editor to bring together an immense amount of information which will often suffice for the purposes for which it is sure to be looked up. The only important drawback to the plan on which this information has been arranged is that it involves too many cross-references. The illustrations are very numerous, and it is worth noting that old cuts have been used only when better ones could not be made. Some are excellent, and most of the others are quite up to the level which ought to be maintained in so important an undertaking. Of the typographical style, it may be enough for us to say that the publishers have succeeded in giving what they desired to produce—a page in which the matter is at once condensed and legible.

Altogether, the work deserves to be warmly welcomed in England. Those who possess it will have within reach the best results that have hitherto been attained as to the meaning, the evolution, and the affinities of all classes of English words.

OUR BOOK SHELF.

List of the Snakes in the Indian Museum. By W. L. Sclater.

THIS list contains the names of 350 species of snakes represented in the collection of the Indian Museum, Calcutta. Of the 350 a large majority, 210, are from the Indian Empire (inclusive of Burma and Ceylon), leaving 68 forms that are known to inhabit parts of British India unrepresented in the collection. When it is remembered how rare and local many snakes are, how many species are known by a single specimen, and how seldom opportunities of collecting occur in such tracts as the remoter hills of Southern India, the Assam ranges, the forests of Tenasserim, &c., which abound in peculiar forms, those who have had charge of the Indian Museum may be congratulated on having succeeded in bringing together representatives of so large a proportion of the Indian Ophidian fauna. The number of species represented in the Museum of the Asiatic Society, the nucleus of the Indian Museum, Calcutta, when the reptiles were catalogued by Mr. W. Theobald in 1865, was about 120, so that there has been an increase of 75 per cent. in 26 years. Altogether, as regards Indian snakes, the Calcutta collection is probably only inferior to that in the British Museum.

The publication of the present list has naturally been greatly facilitated, if indeed it may not be said to have been caused, by the appearance, in 1890, of Mr. Boulenger's work on Indian Reptilia and Batrachia, to which, in his introduction, Mr. Sclater fully acknowledges his obligation. A few species have been added by Mr. Sclater to those described by Mr. Boulenger as inhabitants of British India.

This is probably the last contribution to Indian geological literature that may be expected for the present from its author, who has, according to an announcement in NATURE for January 21, received an appointment at Eton College. During his brief tenure of the Deputy Superintendentship, Mr. Sclater has done some useful work for the Indian Museum, especially in completing the catalogue of Mammalia commenced by Dr. J. Anderson.

W. T. B.

The Living World: Whence it Came and Whither it is Drifting. By H. W. Conn. (New York and London: G. P. Putnam's Sons, 1891.)

IN this book Prof. Conn undertakes to present a review of the speculations concerning the origin and significance of life, and of the facts known in regard to its development, with suggestions as to the direction in which the development is now tending. The subject is certainly large enough, but the author has prepared himself for dealing with it by careful study of the highest authorities in biological science, and he succeeds in giving a clear, impartial, and interesting account of the main lines of inquiry connected with the theory of evolution. He begins with a general chapter on the sources of "biological history," indicating the meaning of evidence from fossils, from embryology and anatomy, and from other departments of research. He then expounds the various ideas which have been suggested as to the origin of life, bringing into prominence two propositions which may be distinguished from mere hypotheses. These are (1) that life arose in the ocean, and (2) that the first form of life was the simplest possible condition of living matter, certainly simpler than any living organisms with which we are acquainted to-day, and very likely simpler than the simplest mass of diffused protoplasm. Next comes a summary of the leading facts and speculations about the origin of the animal kingdom; and this is followed by a chapter setting forth "the record from fossils." The work is completed by a general view of the course of animal evolution, a sketch of the history of plants, and a discussion of various questions relating to the probable future of the living world. A list of references is added, which will be of considerable service to readers who may desire to study more minutely the philosophy of evolution.

Adventures amidst the Equatorial Forests and Rivers of South America; also in the West Indies and the Wilds of Florida. To which is added "Jamaica Revisited." By Villiers Stuart, of Dromana. With many illustrations and maps. (London: John Murray, 1891.)

A GREAT part of this book relates to travels which took place more than thirty years ago. The work is not, however, less interesting on that account, for the impressions recorded in it are reproduced from letters and journals written at the time and on the spot. The author writes without pretension, and has much that is attractive to say about Surinam, Cayenne, Demerara, the Orinoco, Trinidad, Martinique, and Florida. In the chapters on Jamaica he combines the impressions obtained during his first visit with those made upon him in 1891, when he was present at the opening of the Jamaica Exhibition. Mr. Stuart writes of this island with the strongest enthusiasm. "It is impossible," he says, "to exaggerate its loveliness. The most skilful writers must despair of conveying any adequate idea of its fairy-like charms." He gives an excellent account of the progress made by the people of Jamaica in the interval between his two visits. On all sides he was struck in 1891 by evidences of industry and improvement; and of the coloured population he asserts that they seemed to him the merriest and happiest peasantry he had met with in any part of the world.

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.*]

Cirques.

FROM two or three of the criticisms of the views in my volume on "The Ice Age in America," concerning *cirques*, I concluded that there was some misunderstanding as to the thing signified by the word, and accordingly wrote to Mr. Russell, of our Survey, whose views I had adopted, and who has had wider acquaintance with the facts concerning them than anyone else in America. I send you his reply, which you are at liberty to publish if you wish. I am sure all interested in glacial matters will value a communication from so eminent an authority, and will find that much light is shed upon the subject by his recent explorations in the Mount St. Elias district of Alaska.

G. FREDERICK WRIGHT.

Oberlin, Ohio, U.S.A., December 16, 1891.

Department of the Interior, United States Geological Survey, Washington, D.C., December 12, 1891.

Prof. G. Frederick Wright, Oberlin, Ohio.

MY DEAR SIR,—Your letter, calling attention to Mr. Bonney's remarks on the nature of *cirques* in a review of your "Ice Age in North America" (NATURE, vol. xliv. p. 537), led me to think that possibly all who have written on their character and origin were not considering the same phenomena. This suggestion was strengthened on referring once more to several of the essays which have appeared on the subject. In Bonney's paper on the formation of *cirques* (Quart. Journ. Geol. Soc., London, vol. xxvii., 1871, pp. 312–324), three conditions are mentioned, which are stated to be most favourable to their production; these are :—

"(1) Upland glens, combes, or terraces, so shaped as to give rise to and to maintain many small streams.

"(2) Strata, moderately horizontal, over which these streams fall, which, by their constitution, yield considerably to the other forms of meteoric denudation."

"(3) These strata must nevertheless allow of the formation of cliffs; and thus perhaps the most favourable structure is thick beds of limestone, with occasional alternating bands of softer rock."

In the High Sierra of California—where the *cirques* are situated, my description of which you quote, and which called forth Mr. Bonney's criticism in NATURE—none of the conditions mentioned above, except that the rocks are sufficiently durable to stand in cliffs, have perceptibly influenced the formation of the topographic features under consideration.

The *cirques* are not situated "in upland glens, combes, or terraces, so shaped as to give rise to and maintain many small streams," but are in the very crests of the mountains, and receive practically no drainage from above. They are not in horizontal strata, but in various rocks some of which are highly inclined. The most typical examples occur in granite, which is broken by well-defined vertical joints.

The rocks are sufficiently hard to allow of the formation of cliffs, but this property is requisite for the production of other similar topographic forms, and not an exception peculiar to those in which *cirques* occur.

Not only the *cirques* of the Sierra Nevada, but hundreds of others in the basin ranges of Nevada and Utah, in the Rocky Mountains, and in the mountains of Southern Alaska, have been formed under conditions which are the reverse of those stated by Mr. Bonney.

Another class of topographical forms resembling *cirques* are well known; these are the "alcoves" formed in the edges of *mesas* and table-lands where the rocks are essentially horizontal and usually heterogeneous. They are common in the Catskill Mountains, and all along the borders of the plateau on the west of the Appalachians from New York to Alabama. They occur in the great plateau regions of New Mexico and Arizona, and are common in the cañon walls along the Green and the Colorado Rivers, where they were studied by Powell. Modified examples occur in the sediments of Lake Lahontan, and in the bad lands of Dakota, but in these instances the strata are mostly too soft to stand in vertical walls. I have seen good examples at Table Mountain, Cape of Good Hope, and it is safe to say they will be found wherever nearly horizontal rocks, sufficiently durable to form cliffs, have been cañoned or eroded into *mesas*.

The mode of formation of alcoves is too well known to require detailed description. They are formed by the action of streams cutting niches in precipices, which are enlarged by the dashes of spray from water-falls, by solution, and by the grinding of *débris* in the pools into which waters cascade. Alcoves are most abundant in comparatively low regions, for the reason that when strata are greatly elevated, they usually become inclined or folded; but there is no reason why they should not be found at any altitude, provided the rock conditions favour their formation.

It seems to me that alcoves, and not *cirques*, were formed under the conditions postulated by Mr. Bonney, and that the two are genetically distinct.

Since writing the account of the *cirques* of the High Sierra, quoted by you in "The Ice Age in North America," I have visited the Southern Appalachians and the high mountains of Southern Alaska, always having the various problems of mountain sculpture in mind. The Southern Appalachians are without evidence of former glaciation, while the mountains of Southern Alaska are now undergoing intense glaciation. In the former, *cirques* are absent, but in the latter they are abundant, especially on the northern sides of the crests of the mountains, and are the sources from which numerous glaciers flow.

The initiation of rain and rill sculpture is well illustrated on the sides of many of the valleys of Southern Alaska; and, as you are well aware, there are many valleys in that region which were formerly filled with glaciers to a depth of 2000 feet or more, but from which the ice has now disappeared. All the minor features due to aqueous erosion on the sides of the valleys, previous to their occupation by glaciers, were removed by the ice. The surfaces were cleared of their old records as the sculpture on ancient monuments was sometimes removed to make room for a new bas-relief. When the ice melted, it left the steep slopes without vertical lines, but more or less deeply scored in horizontal bands. Through analogy with the pene-planes described by Davis, we might call these "pene-slopes." The rain falling on these slopes initiated new lines crossing the glacial grooves at high angles, and forming miniature cañons, which receive numerous branches in their upper courses. Many times, several small stream channels coming together have cut radiating channels separated by buttresses, while below, the stream plunges over cascades or runs through deeply-cut gorges. This miniature sculpture is characteristic of immature drainage on inclined surfaces. The combined excavations made by several tributaries near the heads of these new drainage channels have a somewhat basin-like form, but the interiors of the basins are rough, and divided by ridges, and their walls, although steep, do not approach the vertical. These topographic forms in miniature are clearly the work of rain and rills, and have no complicating conditions, except the nature of the strata in which they are cut, and in the best examples this is homogeneous.

Let us renew our studies in the Southern Appalachians, where, as already stated, no evidence of former glaciation has been detected. About many of the higher summits in that region there are large conical depressions, on the sides of which are many rill channels that converge towards a common outlet. These depressions are many times strikingly crater-like in form, but their sides are sloping, and usually deeply covered with *débris*, but in no instance are they vertical cliffs. So far as can be judged, these depressions are not dependent on rock structure, and are certainly not confined to horizontally bedded rocks, but in the best examples have been excavated in strata that are highly inclined. They occur near the summits of mountains and on the sides of precipitous ridges, and receive little if any drainage from above. They belong genetically to the same class as the miniature excavations on the pene-slopes of Alaska, but are of far greater size; and owing to the disintegration and decay of the rocks, and probably, also, to their fuller development, are much more uniform in contour.

The depressions about the summits of the Southern Appalachians are not *cirques*, but in my opinion, are of the nature of the *prototypes* of *cirques*. The general outline of the model has been secured; but for the final sculpturing, in order to form typical *cirques*, another tool is required. That tool is ice.

Should a climatic change occur which would admit of the accumulation of perennial snow about the summits of the Appalachians, the depressions referred to would be the first to be filled, and would give origin to ice streams of the Alpine type. The *névé* snow accumulating in these depressions would become compacted at the bottom and form glacial ice. As the ice flowed outward, it would remove the *débris* encumbering the sides of the basins and attack the rocks beneath, probably in some such manner as described by Lorange, and quoted by you on pp. 244–45 of "The Ice Age in North America."

I do not feel that we can completely analyze the action of snow and ice in depressions like those in which many glaciers originate, but there are certain considerations which may be suggested in this connection.

It is well known that ice may be moulded by pressure and made to flow like a viscous body, while it yields but very slightly to tension. When an attempt is made to stretch it, fracture results. Crevasses therefore indicate tension in the glaciers where they occur.

The crevasses near the upper margins of *névés*, known as *bergschrunds*, are really faults, formed by the subsidence of the *névé* on the lower side of a break. They indicate, as has been suggested to me by Mr. W. J. McGee, that the *névé* where they occur is in a state of tension, and the tendency is for the snow to pull away from the cliffs, and thus tear out portions of the rock to which it adheres. More than this, the crevasses frequently cut completely through the *névé* and expose the rock beneath to the action of frost. In such instances the rocks are in the best position possible to be acted upon by great changes of temperature. Dark bodies on high mountains absorb heat when exposed to the sun, although the air may be below 32° F.; and melting the adjacent snow, become saturated with water, which freezes as soon as they are in shadow. The blocks thus loosened fall away or are removed by the motion of the *névé*. The tops of the cliffs, however, are protected by a covering of snow. There is frequently a space above the top of the *névé* in summer which is exposed in like manner to the action of the atmosphere. These slopes recede by sapping through the action of frost, and precipices result. While the upper portions of the walls of depressions filled with *névé* snow are being broken away by the tensions in the *névé*, and by atmospheric action, the snow on the lower slopes is under compression, and thus rendered capable of abrading the rocks over which it flows.

The ice, in descending the steep slopes from various sides, impinges with great force on the bottoms of the depressions it occupies, and tends to scoop out rock basins. The result of these combined agencies is seen when the *névé* is removed, and we find amphitheatres with precipitous walls rising immediately above a rock basin lake. In other words, the resulting form is a *cirque* like those of the High Sierra.

So far as my observations extend, *cirques* are confined to mountains on which ice sculpture followed water sculpture. The topographic forms left after the disappearance of the ice are modifications of the antecedent forms due to the action of rain and streams.

In the vicinity of Mount St. Elias, Alaska, the mountain ranges are primarily monoclinal uplifts of geologically recent date, and do not bear evidence of having been deeply dissected by streams previous to the birth of the present glaciers. The ice drainage is largely consequent on the present orographic structure, and *cirques* are usually absent. One remarkable exception to this is furnished, however, by a fine *cirque* on the southern side of St. Elias, which is filled by *névé* snows and drained by a small glacier. Thousands of secondary and tertiary glaciers exist on the southern slopes of the mountains, but certainly very few, and so far as my knowledge goes none, of these have their origin in true *cirques*. On the north side of the mountains, however, which are in general the gently sloping surfaces of orographic blocks, topographic forms inherited from former aqueous erosion are conspicuous, and *cirques* are abundant.

Glaciers exist about the summit of Mount Shasta, Mount Ranier, Mount Baker, and other high volcanic peaks in the Cascade Mountains, but none of these, so far as known, originate in *cirques*. These mountains, like the uplifts about Mount St. Elias, are geologically young. They are volcanoes with fumaroles in their craters; and owing to their elevation, and the comparatively slight erosion they have suffered, it is reasonable to suppose that the first precipitation on their summits was in the form of snow. Glaciers were formed on unmodified slopes, but have not excavated *cirques* for themselves. The glaciers on these mountains, like many of the smaller ice streams in Alaska, occur on exposed slopes and not in depressions. The accumulations of snow and ice form prominent convex surfaces and frequently give a characteristic outline to the summits which they cover.

The probable origin of *cirques* which I have traced, together with the fact that they occur in thousands about the summits of mountains on which the glaciers followed water sculpture, together with their absence on unglaciated mountains like the Southern Appalachians, and also the fact that glaciers in themselves do not seem to have the power of excavating similar depressions, is seemingly cumulative evidence pointing to the conclusion stated above.

Cirques, alcoves, and possibly other forms, when considered simply as topographic features, may perhaps be classed together; yet, genetically, alcoves and *cirques* are distinct, the former owing their existence to aqueous sculpture, usually in horizontal rocks, and the latter to aqueous sculpture followed by ice sculpture, in rocks which may be heterogeneous or homogeneous, horizontal or inclined.

The generalization that "*cirques* are confined to glaciated regions," to which Mr. Bonney takes exception, was reached from considering the distribution of typical examples, previous to the differentiation of *cirques* from other similar topographic forms. When they are recognized as distinct from alcoves, and necessarily in part of glacial origin, the reason for their distribution becomes evident, as does also the further generalization that they "occupy localities where glaciers first appear."

In the Rocky Mountains the peaks and ridges on which *cirques* occur have an elevation of from 10,000 to 14,000 feet. The same is true also in the Sierra Nevada. In each of these regions the ancient *névé* fields had generally about the same elevation, while the glaciers flowing from them descend to within 6000 or 5000 feet above sea-level. In Alaska, however, where the former glaciers descended into the ocean, *cirques* occur on peaks and ridges only 3000 or 4000 feet high, and examples may be found at elevations of less than 2000 feet. Their vertical, as well as their geographic range, therefore, appears to have been regulated by the climatic conditions which control the birth of local glaciers.

While "alcove" and "*cirque*" should have a definite significance in geology, amphitheatre, recess, bowl, and other correlative words, may be considered as general terms applicable to more or less inclosed spaces without reference to their origin. The semicircular recesses made by winding streams in the sides of cañons and deep valleys, sometimes resemble alcoves. Craters frequently bear a close topographic similarity to *cirques*, but are readily distinguished when their origin is considered.

On looking over my account of the *cirques* of the High Sierra (Eighth Annual Report, 1886–87, U.S. Geological Survey), I fail to discern any reason for materially changing it, except, as indicated above, to state more definitely the differences between cirques and other topographic forms with which they might be confounded.

I remain very sincerely your friend,
ISRAEL C. RUSSELL.

Large Meteor of January 24, 1892.

IT is to be hoped that further observations wlll be forthcoming of the brilliant meteor of January 24, 10h. 55m. (described by Mr. T. Heath in your last number, p. 295), so that its real path may be computed. I think there is little doubt the meteor belonged to a shower of Draconids having a radiant-point a few degrees south-east of the star ζ. On the same night (January 24) as that on which the fine meteor was observed, I saw a third magnitude shooting-star, at 7h. 55m., with a path from $324° + 40°$ to $330\frac{1}{2}° + 31\frac{3}{4}°$, and this also belonged to the radiant in Draco. I discovered this shower on the nights of January 19 and 25, 1887, and determined the position of the radiant as at $261° + 63°$. There are many other showers from the same point in the spring, summer, and autumn months.

Bristol, January 31. W. F. DENNING.

On the Relation of Natural Science to Art.

IN Dr. du Bois-Reymond's interesting lecture, as published recently in NATURE, there occurs the following passage (p. 226): "Flaxman" was "certainly mistaken in representing Polyphemus with three eyes—two normal ones which are blind, and a third in the forehead." Does not the recent discovery of a third (parietal) eye in some of the lizard and fish tribes (not to mention the tunicates!) diminish the force of this assertion? Flaxman's genius appears rather to have forestalled the discoveries of science in representing the human monster with three eyes, especially as Wiedersheim states that even in man nerve-fibres have been traced from the optic thalami to the pineal gland. W. AINSLIE HOLLIS.

Brighton, January 11.

Ice Crystals.

THE following account of some very well defined ice crystals may be of interest.

On December 26, 1891, the thaw set in. On the 27th, I noticed on the surface of the ice on the lake at Drinkwater Park, near Prestwich, on the outskirts of Manchester, a large number of very distinct, hexagonal, tabular crystals. The surface of the ice was not very wet. These crystals varied from half an inch to three inches across, were raised about an eighth of an inch above the surface of the ice, and in many cases bore a similar but much smaller crystal in the middle, raised about an eighth of an inch above the surface of the larger crystal. In some specimens the smaller crystal was rounded and indistinct. When it was absent, dark lines, following the direction of the lateral axes, were visible in some cases. Frequently an indistinct striation was present. GILBERT RIGG.

Manchester Museum, Mineralogical Department, January 12.

A Tortoise inclosed in Ice.

I SHOULD like to be allowed to record a case of a water-tortoise surviving an incarceration in ice, somewhat similar to that given in NATURE (vol. xliv. p. 520).

In this instance, the tortoise has hibernated in a stone basin, in which there were about 6 inches of water and a quantity of dead leaves. The whole was, I believe, frozen into a solid mass. At any rate, when, on December 29, I examined a cake of ice and leaves, from 2 to 3 inches thick, which was floating in the basin after a thaw, I found the tortoise with its back embedded in the *under* side of the mass, and with nearly 2 inches of porous-looking ice above it. The animal, though torpid, was alive, and I replaced it in the basin. Later on it put its nostrils up to the surface, and two days afterwards was seen with its head out of the water as usual. It remained in the pond, which has been again frozen over, in less than a week after this observation. FRANK FINN.

31 Walton Crescent, Oxford, January 22.

Alpine Rubi.

IN a footnote in NATURE (vol. xlv. p. 10) it is stated that "The two highest-known species of *Rubus* are *pinnatus* and *rigidus*, at 5000-6000 feet." This is hardly correct, unless it is intended to refer to African species only. In South America, *R. megallococcus*, *R. boliviensis*, *R. bogotensis*, and *R. roseus* occur at 8000 feet, and *R. rusbyi* at 10,000. In Colorado I have found *R. strigosus* above 10,000 feet (see *Bull. Torrey Bot. Club*, 1890, p. 10; 1891, p. 169). In the Indian region, *R. ellipticus* goes to 7000, *R. lasiocarpus* to 8000, and *R. biflorus* and *R. rosifolius* to 10,000 feet.

The name of the wild *Zea* is *Z. canina*, Watson (local name, "mais de coyote"), not *nana*, as given in NATURE, vol. xlv. p. 39. T. D. A. COCKERELL.

Institute of Jamaica, Kingston, Jamaica, December 30, 1891.

UTILIZATION OF HOMING PIGEONS.

THE utilization of the homing instinct of the domesticated varieties of the blue rock pigeon, the *Columba livia*, for military purposes, has been effected by most of the Governments in Europe. In France, Germany, Austria, Switzerland, Italy, Spain, and Portugal the organization has been very complete. It has even extended to Russia, Denmark, and Sweden; and Africa has been brought into communication with Spain by stations at Ceuta and Mellila. England alone, of all the great Powers, has neglected this important mode of communication, which is available under circumstances that preclude the employment of any other means.

It cannot be said that they have not been brought under the notice of the military and naval authorities. Nearly twenty years ago, on the occasion of the despatch of a flight of seventy-two birds from the Crystal Palace to Brussels, when the first birds arrived before the telegram which was sent to announce their departure, I wrote a letter to the *Times* of June 27, 1873, calling attention to their utility, and asking the question: "What would be the value of the birds, in the event of a war in which we may be engaged, that would convey messages to or from Guernsey, Jersey, and other places, when the submarine wires had been cut by the enemy?"; and in a lecture delivered by me before the Royal Engineers' Institute at Chatham, on the use of pigeons for military purposes, I entered at some length into their mode of training and general utilization.

The employment of the *Columba livia* depends upon several conditions which are not without interest. In the first place, this species is one of the comparatively few capable of domestication, a faculty which is totally distinct from, though frequently confounded with, the facility of being tamed. A domesticated animal is attached to its home, and returns to it of its own will; a tame animal is merely familiar with man. These two states are admirably illustrated in the closely allied species, the fowl and the pheasant. Both were originally perfectly wild, but when domesticated the chickens invariably return home to roost, while the pheasants, though descended from numberless generations of birds bred in confinement, have no attachment whatever to the place of their birth or rearing.

In its natural habitat (the rocky cliffs of the sea-shore) the blue rock pigeon has to fly long distances in search of food, which, when breeding, it stores up in its crop and carries home to its young. This necessitates strong powers of flight and well-developed perceptive faculties, it being guided in its return solely by sight, and not, as is often supposed, by any special instinct.

The pigeons that are used for carrying messages are bred solely for that purpose. A process of artificial selection, as rigorous and remorseless as that of nature, is followed. The young birds, after acquiring their power of perfect flight, and learning the contour of the country in their circuits around their home, are taken in

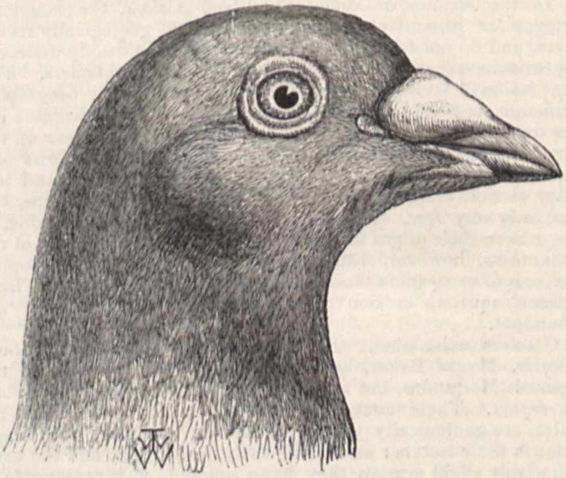

FIG. 1.

the direction in which it is desired that they should fly, and trained stage after stage until they know every locality over which they have to traverse. This training is absolutely necessary, if their return home is to be depended on. During its performance the inferior birds, those whose intelligence and determination are not well developed, are lost; and the best birds, only, retained. This loss, in the long-distance flights which are flown by the Belgians and by the best homing pigeon societies in England, is very severe. Old birds, that know large tracts of country well, may be taken in new directions, provided they are not too extended, with safety, but young birds that have not been trained would almost certainly be lost if carried many miles from their home.

Every homing pigeon flyer recognizes the hereditary character of this acquired faculty, and will give a very high price for birds descended from parents that have flown long distances, whereas he would not purchase another bird of precisely similar appearance were he not acquainted with the performances of its ancestors. The fancy varieties of pigeons, especially those which are called carriers in England, are perfectly useless for the purpose of flying distances.

The birds that are most valued are almost all descended from the homing pigeons, *les pigeons voyageurs*, of Belgium, in which country the sport of pigeon racing has been carried on for many years, and has attained its highest development. Pigeon races, in which thousands of birds are engaged, take place annually from the south of France, a distance of five hundred miles, to Brussels and the neighbouring parts of Belgium. The birds are characterized by a well-developed brain, hard, firm plumage, great breadth of the primary and secondary flight feathers, and large pectoral muscles. Fig. 1 is an accurate portrait of a homing pigeon formerly in my possession that had repeatedly flown from the south of France to Brussels. Their rate of flight, for long distances, depends, of course, greatly on the weather. With a strong adverse wind their progress is necessarily slow compared with what it is when the wind is in their favour, but the rate of the winners may be taken from eight hundred to thirteen or fourteen hundred yards per minute. In favourable weather the races from the south of France to Brussels are usually accomplished by the winners in one day, the pigeons never flying after eight o'clock in the evening, the birds being liberated at daylight in the morning. Fog and mist, hiding the surface of the country, are fatal to rapid progress.

It is sometimes alleged that sight can be of no avail when birds are liberated some hundreds of miles from their home, but it should be remembered that from an elevated position in the atmosphere immense distances can be seen. Mr. Glaisher records that from a balloon he saw at the same time the cliffs of Margate on the west,

FIG. 2.[1]—CHART SHOWING THE SYSTEM OF MILITARY PIGEON POSTS IN THE CONTINENTAL KINGDOMS.

FRANCE: 1, Mont Valérien; 2, Paris; 3, Vincennes; 4, Lille; 5, Douai; 6, Valenciennes; 7, Maubeuge; 8, Mézières; 9, Verdun; 10, Toul; 11, Langres; 12, Belfort; 13, Besançon; 14, Lyon; 15, Marseille; 16, Perpignan; 17, Grenoble; 18, Briançon.
PORTUGAL: 1, Lisbonne; 2, Porto; 3, Valence; 4, Chaves; 5, Bragance: 6, Almeida; 7, Guarda; 8, Coimbre; 9, Castello Branco; 10, Abrantès; 11, Elvas; 12, Peniche; 13, Beja; 14, Lagos.
ESPAGNE: 1, Madrid; 2, Figueras; 3, Iaca; 4, Pamplona; 5, Oyarsun; 6, Ferrol; 7, Ciudad-Rodrigo; 8, Badajoz; 9, Tarifa; 10, Ceuta; 11, Melilla; 12, Palma; 13, Mahon; 14, Zaragoza; 14, Valladolid; 16, Cordoba; 17, Malaga; 18, Valencia.
ITALIE: 1, Rome; 2, Ancone; 3, Boulogne; 4, Vérone; 5, Plaisance; 6, Alexandrie; 7, Mont Cenis; 8, Fenestrelle; 9, Exiles; 10, Vinadio; 11, La Maddalena; 12, Cagliari; 13, Gaeta; 14, Génova.
SUISSE: 1, Thun; 2, Bâle; 3, Zurich; 4, Weesen.
ALLEMAGNE: 1, Berlin; 2, Cologne; 3, Metz; 4, Mayence; 5, Wurtzbourg; 6, Strasbourg; 7, Schwetzingen (en projet); 8, Wilhelmshaven: 9, Tonning 10, Kiel; 11, Stettin; 12, Dantzig; 13, Kœnigsberg; 14, Thorn; 15, Posen; 16, Breslau; 17, Torgau.
AUTRICHE: 1, Comorn; 2, Cracovie; 3, Franzenfeste: 4, Karlsburg; 5, Serajewo; 6, Mostar; 7, Trieste.
DANEMARK: 1, Copenhague.
SUÈDE: Carlsborg.
RUSSIE: 1, Brest-Litovsk; 2, Varsovie; 3, Novo-Georgievsk; 4, Ivangorod; 5, Luninetz.

[1] We are enabled by the courtesy of the editor of *La Nature* to reproduce this map.

Brighton on the south, and all along the coast-line to Yarmouth on the north.

The homing-by-instinct theory is entirely disproved by the races which have taken place from Rome to Belgium, a distance of between eight and nine hundred miles, nearly half of which was over country entirely new to the birds. All the birds engaged in these races had been flown from the south of France to Belgium, whence they would have found their way back in one or two days, but of the hundreds liberated in Rome, not one returned before eleven days, and in the first race in a fortnight only four out of the number despatched. The country was new to them, and doubtless they circled about in search of some known landmark which would have directed their flight; but the objects with which they were acquainted were hidden from them by the Alps, and it was only those few that, flying along the coast, succeeded in reaching the south of France, and then saw objects with which they were acquainted, that returned to their Belgian homes.

The first extensive practical application of the homing faculty of these birds took place when Paris was environed by the German army. During the siege, as is well known, balloons were continually despatched from Paris, carrying not only passengers, but bundles of letters, and the homing pigeons belonging to a few private individuals resident in Paris. In the first instance the despatches returned by these pigeons were photographed on paper and sent from Brussels into Paris. After a time a distinct pigeon post was organized from Tours, outside the German lines. This pigeon post was recognized by the English postal authorities, and letters at the cost of half-a-franc a word were sent from Tours into Paris with as great a degree of rapidity as the pigeons could be sent out by balloon, and conveyed from the places where they descended to Tours, for the purpose of being reflown into Paris. The letters, which were limited to twenty words, were set up in type, micro-photographed on thin films of collodion, inclosed in small quills, and attached to one of the tail feathers of the bird. So complete was this organization that one pigeon could have carried into Paris the whole of the many thousand letters that were sent in during the siege.

The Germans were not slow to utilize the services of the pigeons for military purposes, and at the present time every large fortress in Germany has its pigeon loft, and the birds are trained to fly back from the surrounding country for distances of many miles.

As will be seen by the accompanying map (Fig. 2), pigeons are trained to Berlin from all the large fortresses in the Empire, Strasbourg on the south to Kœnigsberg on the north. Then, again, each fortress has its own loft of pigeons, which are trained to fly back to it, so that before a fortress is completely invaded by the enemy a number of birds can be sent out, or forwarded subsequently by balloon. On being liberated with despatches, these would return to the fortress, without the possibility of their being interfered with. A similar organization prevails in France, pigeons having been trained from Paris to all the military stations on the German frontier; and it may be observed that in Italy, Austria, and even Russia the same system prevails. In our own country there is no definite organization of pigeons for military purposes. It is true pigeon flying has become a popular pastime with a large number of persons. There is scarcely a town in the kingdom where some good homing birds do not exist, which could be placed at the disposition of the military or naval authorities. One great use of the birds would be on the cruisers sent out to watch an enemy's fleet. It is obvious that each could readily take a number of pigeons on board, and, without leaving its post of observation, could send back day by day messages to the town from whence the pigeons were received.

It is doubtful whether any purely military organization could take as good care of the pigeons, and could train them in a manner superior to that which is done by those who use them for racing purposes. No military or naval servant, unless he were a lover of pigeons, would train them with the same amount of interest and care that is done by the amateurs.

In this country, at the present time, there exists a very large number of pigeon-flying Societies. Their races extend from the midland counties in England as far as Cherbourg, and other parts of France. In actual practice the birds would not be, except under very rare occurrences, required to fly very long distances. Of course these long flights necessitate a considerable amount of risk, but good pigeons can be calculated on to return from fifty to a hundred miles with certainty.

On looking at the map it will be seen that no lines showing the military organization of pigeons appear in Belgium; in fact, it is hardly thought necessary that any distinct organization should take place there, as it is supposed that there are in Belgium alone more than six hundred thousand homing pigeons belonging to private individuals, all of which are well trained, and would, in case of war, be placed at the disposition of Government.

W. B. TEGETMEIER.

NOTES.

THE Committee which has been formed for the purpose of obtaining a portrait of Michael Foster, Secretary of the Royal Society, and Professor of Physiology in the University of Cambridge, has issued a second list of subscriptions. It is intended that the picture shall be presented either to the University or to Trinity College, as the subscribers may decide. The treasurer is Dr. Lea, Gonville and Caius College, and subscriptions may be paid either to him or to Messrs. John Mortlock and Co., Bankers (Limited), Bene't Street, Cambridge. Cheques should be made payable to the "Michael Foster Portrait Fund."

AT the meeting of the Cambridge Philosophical Society on Monday, January 25, Prof. G. H. Darwin, President, in the chair, the following resolutions were proposed by Prof. Cayley, seconded by Dr. Lea, and passed unanimously:—"(1) That the Cambridge Philosophical Society desires to express its sense of the great loss sustained by the University and the Society by the death of Prof. Adams, who shed lustre on the Society by the brilliancy of his scientific career, and set an example to its members by the earnestness and simplicity of his life. (2) That the Society do now adjourn without transacting the business of the meeting, as a mark of respect for the memory of Prof. Adams, one of the benefactors of the Society. (3) That the President be instructed to convey the foregoing resolutions to Mrs. Adams."

WE have heard at present of only one astronomer as candidate for the Professorship of Astronomy rendered vacant by the death of Prof. Adams; this is Mr. Turner, Chief Assistant at Greenwich. On the other hand, we hear of some mathematicians; it is not stated, however, what contributions to the science they have made.

THE late Ferdinand Roemer, the well-known geologist and Professor at the University of Breslau, whose death on December 14, 1891, we have already recorded, intended to have celebrated on May 10 next his jubilee as a Doctor of Philosophy; and his friends, admirers, aud pupils were preparing to do him honour on the occasion. It is now proposed that a marble bust of Roemer shall be placed in the Mineralogical Museum of Breslau, and an influential committee has been formed for the purpose of collecting subscriptions.

THE Committees appointed last year by the Royal Society and by the British Association for investigating the zoology of the Sandwich Islands have amalgamated, and at a meeting held one day last month selected, from among the gentlemen who offered their services, Mr. Robert C. L. Perkins, B.A., of Jesus College, Oxford. Mr. Perkins will accordingly leave England in a few days, proceeding *viâ* New York and San Francisco to Honolulu, where he will at once commence his researches into the fauna of the islands, and especially that part of it which is believed to be threatened with extinction; aided, it is hoped, by the Hawaiian Government, and some of the principal residents. Dr. David Sharp, F.R.S., Curator in Zoology in the Museum of the University of Cambridge, is the Secretary of the Joint Committee.

THE annual general meeting of the Geological Society will be held on Friday, February 19, at 3 p.m., and the Fellows and their friends will dine together at the Hotel Métropole, Whitehall Place, at 7.30 p.m.

THE new law on French Universities is soon to be discussed by the French Senate. The Committee appointed to report upon the Government's plan disapproves of many of its provisions.

M. PIERRE LAFFITTE, the head of the "orthodox" Positivists, has been appointed professor, at the Collége de France, of the history of science.

DR. FRIDTHOF NANSEN is now in England, his object being to fulfil a series of lecture engagements. The proceeds are to be devoted to the expedition to the North Pole on which he hopes to start next year.

THE Joint Grand Gresham Committee has decided to co-operate with University and King's Colleges and the Medical Colleges of the great hospitals of London in the establishment of the proposed University in and for London, on the understanding that it be called the Gresham University.

DR. ALFRED CARPENTER, the well-known advocate of sanitary reform, died at Ventnor on January 27. He was the author of many works on sanitary subjects. In 1879 he was elected President of the Council of the British Medical Association, having been in the previous year orator of the Medical Society of London.

PROF. E. RAY LANKESTER will on Thursday next (February 11), at the Royal Institution, begin a course of three lectures on "Recent Biological Discoveries"; and Lord Rayleigh will on Saturday (February 13) begin a course of six lectures on "Matter: at Rest and in Motion."

DR. NOETLING, of the India Geological Survey, is now engaged in superintending the sinking of shafts at the amber mines on the Upper Irrawaddy.

AN index to the five yearly volumes of the *Kew Bulletin*, already published, has now been issued as "Appendix IV., 1891." In an introductory note some interesting statements are made as to the history of the *Bulletin*. It was originally intended that a number should be issued only occasionally; but monthly publication was immediately found to be necessary, and further space has since been obtained by the printing of information of a purely formal kind in appendices. The subjects treated have related almost entirely to economic botany. The results of investigations made by members of the staff at Kew and of kindred institutions at home and abroad on vegetable products and the plants producing them, have been carefully summarized and presented in as concise and clear a manner as possible. In many cases the articles have been illustrated by plates from original drawings or by those placed at the disposal of the Director by the Bentham Trustees from the "Icones Plantarum." The *Bulletin* has become a most convenient mode of communicating information to persons at home, to the numerous correspondents officially connected with colonial and Indian botanical establishments, and to private persons interested in plant products in distant parts of the Empire. It has also been of service to members of the general public engaged in planting or agricultural business in India and the colonies.

THE fourth part of the first volume (xxi. of the whole work) of the fourth series of Hooker's "Icones Plantarum" has appeared, completing this volume, which is devoted to the illustration, by Sir Joseph Hooker, of Indian orchids of a less conspicuous character than those commonly cultivated. The work is now published for the Bentham Trustees, and sold at four shillings per part by Dulau and Co., of London. The third series, consisting of ten volumes, containing 1000 figures of interesting plants, is on sale by the same firm, at £5 the set. Only a limited issue is printed, and when exhausted it will not be reproduced.

MR. ELLSWORTH has offered to lend for exhibition at the "World's Fair," Chicago, a collection of orchids, including between 1500 and 2000 varieties.

THE Chemical Institute of the Royal University, Rome, has printed a volume of reports on the researches carried on by its workers during the scholastic year 1890–91. Excellent service might be done to science if this example were followed by the laboratories connected with our own Universities.

THE Director of the Colonial Museum at Haarlem has issued a circular notice to the effect that it is of the highest importance for the Museum to have in its library all recent treatises on tropical botany, zoology, products, and cultivation. He begs therefore that authors will send to the Museum a printed copy of their writings on these subjects in the publications of scientific Societies.

THE *Times* of Tuesday, February 2, contains an account of a very peculiar case of prolonged sleep which, on January 31, was occupying the attention of medical circles in Germany. It seems that a miner named Johann Latus, an inmate of the hospital at Myslowitz, in Silesia, has been there 4½ months, and during that time all attempts that have been made to wake him have been fruitless. The doctor attending him, Dr. Albers, thinks that catalepsy is the real cause of his condition, although no previous record of so prolonged a sleep has ever been made in medical science. The fact which has led Dr. Albers to this conclusion is that all the limbs are absolutely rigid. In other respects the appearance of the man betrays no sign of this. The body remains quite still, breathing takes place regularly, and the appearance of the face is quite normal, the cheeks being of a healthy colour. Lately the body has been less rigid and the patient has even made some slight movement, but the eyes have still been kept closed, and the condition of apparent sleep in no way disturbed. During this long sleep the hair on the head has increased in length, but the beard has remained stationary. In order to supply the patient with food a tube has been inserted into the throat, and by means of it two or three litres of milk have been administered daily.

M. KOEBELE, who has been for the second time searching in Australia and New Zealand for "beneficial insects," has discovered that *Orcus chalybeus*, a steel-blue ladybird, is a most important enemy of the red scale. According to *Insect Life*, he has found them by the hundred, and has observed the mature insects eating the scales. The trees were "full of eggs," and the larvæ were swarming on all the orange and lemon trees infested with the red scale. M. Koebele has sent to America a large quantity of the eggs and many of the adult beetles.

ACCORDING to the Berlin correspondent of the *Times*, a curious rosy light overspread the sky above Berlin from 9 till 11 o'clock on the evening of January 26, and made many people think that a great fire had broken out somewhere. Early on the following morning the Emperor telephoned to the central fire brigade station to inquire what had happened, but received answer that the effulgence was a natural phenomenon.

IN March 1891, a Select Committee of the House of Commons was appointed to consider the subject of the registration of teachers. Two Bills which had been introduced into the House of Commons, one by Sir Richard Temple, the other by Mr. Arthur Acland, were referred to the Committee ; and it examined a large number of witnesses whose opinions were worthy of being carefully considered. The Report of this Committee has been issued by the National Association for the Promotion of Technical and Secondary Education, and deserves the attention of all who are interested in educational questions. The following are the conclusions at which the Committee arrived : that the registration of teachers in secondary schools is in principle desirable ; that any Educational Council to be established for the furtherance of such registration should be composed of nominees of the State, representatives of the Universities, and members elected by the teaching profession ; that the qualifications for registration should include evidence both of attainments and of teaching capacity ; and that additional facilities are required for the training of teachers in secondary schools. The Committee was of opinion (*a*) that existing teachers should not be put on the register merely as such, but should not suffer from any legal disability ; (*b*) that both existing teachers and future teachers should be admitted to the register on producing such evidence of intellectual acquirements and teaching capacity as might be required by the Council ; (*c*) that the register should, as soon as might appear reasonable in such case, be made compulsory upon existing teachers in the event of their appointment to teach in a secondary school, assisted by endowments or public money, and upon future teachers in these, and ultimately in all other secondary schools ; (*d*) that teachers certified by the Education Department should be placed on the register, with an indication, as in the case of other teachers, of the nature of their certificate.

THE Committee on the Indexing of Chemical Literature, appointed by the Chemical Section of the American Association for the Advancement of Science, refers with pleasure, in its ninth annual report, to the fact that a new Dictionary of Solubilities is in progress by a competent hand. Prof. Arthur M. Comey, of Tufts College, College Hill, Massachusetts, has written to the Committee that the work he has undertaken will be as nearly complete as possible. He estimates that the dictionary will contain over 70,000 entries, and will make a volume of 1500 to 1700 pages. The arrangement will be strictly alphabetical, and in all cases references will be given to original papers. The Committee also prints a letter in which Mr. Howard L. Prince says that in the U.S. Patent Office, of which he is librarian, an index is being made for about 150 journals, notably those upon the subjects of chemistry, electricity, and engineering, both in English and foreign languages. The general plan is alphabetical, but he departs from it sufficiently to group under such subjects as chemistry, electricity, engineering, railroads, &c., all the subdivisions of the art, so that the electrical investigator, for instance, will not have to travel from one end of the alphabet to the other to find the divisions of generators, conductors, dynamos, telephones, telegraphs, &c. Another fact mentioned by the Committee is that an extensive bibliography of mineral waters is being prepared by Dr. Alfred Tuckerman.

THE Institute of Jamaica has begun the issue of special publications. The first, the Rainfall Atlas of Jamaica, contains thirteen coloured maps showing the average rainfall in each month and during the year, with explanatory text. The maps are based upon observations made at 153 stations from about the year 1870 to the end of the year 1889. The available stations are irregularly distributed, being for the most part sugar-estates and cattle-pens, and in consequence of this irregularity the island has been divided into four rainfall divisions. The north-eastern division has the largest rainfall, then comes the west central, next the northern, and lastly the southern. The annual distribution of the rainfall varies from 30 to 35 inches in a few places to over 100 inches in the north-eastern division. The greatest fall is in October, and the least in February. The driest stations are on the north-eastern and south-eastern shores. The maps show the distribution and average amount of rainfall very clearly by different tints, and cannot fail to be of both scientific and practical utility. The work has been prepared by Maxwell Hall, the Government Meteorologist.

IN the new number of the *London and Middlesex Note-book*, Mr. G. F. Lawrence says that some months ago he obtained a stone hammer of unusual form from the Thames at Hammersmith. It is in the form of a cushion, and is beautifully polished all over. The shaft-hole is $\frac{13}{16}$ inch in diameter, and is an inch nearer one end than the other. The material is a beautifully veined claystone, of a light greenish colour, and the hammer measures $4\frac{1}{8}$ inches in length, $2\frac{1}{8}$ inches broad, and is $1\frac{1}{8}$ inch thick. Mr. Lawrence knows of only two other specimens of this type which have been found in the southern counties ; both are in the British Museum. The Edinburgh Museum, however, contains several, some of handsome material and finish, while others are of a less beautiful, but most serviceable granitic stone. The type seems to belong to the Bronze Age. Such specimens as the Hammersmith example must have been, Mr. Lawrence thinks, more than mere implements. He suggests that they were symbols of chieftainship, and handed down from one to another, as sacred badges of office, as the beautiful jade weapons were in New Zealand.

MR. E. P. RAMSAY, Curator of the Australian Museum, Sydney, has reported to the trustees that during the year 1890 no fewer than 320 specimens were bought for the ethnological collections. The most important of them were a fine lot of greenstone axes and old clay cooking-pots from New Caledonia ; fine-made mats, baskets, hats, native hair lines and fishing hooks, from Gilbert and Kingsmill Group ; necklaces, drums, and other rare articles of native dress, from British New Guinea ; clubs, spears, cava-bowls, and food-baskets, from Viti or Fiji ; stone-headed spears, from Bathurst Island, Torres Straits. Among 74 specimens acquired by exchange were a valuable collection of Neolithic worked flints from the Chalk Hills, South Downs, England ; worked flints, from the Thames ; Palæolithic worked flints, from the river gravels, near London ; polished basalt celts, from Ireland ; celt socket, formed of the base of the red-deer, from Swiss lake-dwellings ; old English flint and steel, from Yorkshire ; modern French peasant's pipe-lighter, flint and steel ; iron lamp, or "cruzie," in use since Roman times in Scotland ; brass lamp, being a modification of the "cruzie," from Antwerp ; cornelian arrow-tips, from Arabia ; photographs of Hindu pipes.

AN excellent hand-book on "Viticulture for Victoria" has been issued by the Royal Commission on Vegetable Products in that colony. The work has been compiled by Mr. François de Castella, of whom the Commission says that from training and experience he is especially qualified for the task of preparing a manual for vine-growers. During the last few years a fresh impetus has been given to this industry in Victoria, and Mr.

Castella is of opinion that the amount of wine produced in the colony will soon be very considerable. He recommends that the vine-growers of each district should agree among themselves to produce only one definite type of wine, and that it should be known by the name of the district—such as Rutherglen, Great Western, Bendigo, Mooroopna, and so forth. The label on a bottle would thus give some idea of the contents. To name wine from the sort of grape is useless. Two Rieslings—for instance, one grown on the Yarra and the other on the Murray —differ as much as hock and sherry.

MR. CLEMENT REID read an interesting paper the other evening before the Norfolk and Norwich Naturalists' Society on the natural history of isolated ponds. He selected as typical examples the isolated ponds dug on the South Downs to store water for cattle. These ponds are from 300 to 400 feet above sea-level, supplied by rain and condensation, and quite unconnected with any stream, often far from a road or path; and it appears most unlikely that seeds of the plants, or eggs of the animals, which he found in considerable numbers and variety, can have been conveyed thither by human agency. Both the eggs and the seeds must, he thinks, have been transported chiefly on the feet of birds.

MESSRS. LONGMANS have in the press and will shortly publish a new and revised edition of Sir Philip Magnus's "Lessons in Elementary Mechanics." The book, which has already passed through seventeen editions, has been entirely re-written by the author. It contains several new sections, and especial attention has been given to the subject of units and to the explanations of terms. No change, however, has been made in the general arrangements of the book. A key containing full solutions of all the exercises and examination questions, many of which are new, is ready for press, and will be published about the same time as the new edition.

A BOOK by Prof. A. Targioni Tozzetti on the insects and other animals which injure tobacco has recently been published. Of his 300 pages of text, 270 are devoted to insects, 6 to vertebrates, 7 to snails, 10 to arachnids, and 1 to earthworms. Dealing with the cigarette beetle (*Lasioderma serricorne*), which, of all tobacco insects, does most damage in America, Prof. Tozzetti recommends as a remedy a thorough use of chloroform, bisulphide of carbon, and hydrocyanic acid gas in disinfecting warehouses and manufactories; and he advises, where possible, the submersion of the tobacco in 90 parts of water for forty-eight hours. *Insect Life* says of this advice that it is "evidently not based on experience, and not appreciative of the ease with which tobacco is spoiled for the trade."

IN the last sentence of Mr. Frederick J. Smith's letter on "A Simple Heat Engine" (NATURE, p. 294), *for* "fall" *read* "pull."

A SERIES of remarkable compounds of the halogen salts of the rare metal cæsium with two more atoms of chlorine, bromine, or iodine, are described by Messrs. Wells and Penfield in the January number of the *American Journal of Science*. The fact was accidentally discovered that when bromine is added to a concentrated solution of cæsium chloride, CsCl, a dense bright-yellow precipitate is produced. When the contents of the test-tube are warmed, this precipitate dissolves, but on cooling the same substance separates out in the form of large orange-coloured crystals. Upon analysis these crystals are found to possess the composition $CsClBr_2$. This remarkable observation has led to the preparation of a series of eight such salts, each containing one atom of cæsium and three halogen atoms. The formulæ of these compounds are CsI_3, $CsBrI_2$, $CsBr_2I$, CsClBrI, $CsCl_2I$, $CsBr_3$, $CsClBr_2$, and $CsCl_2Br$. They all crystallize well, generally in large brilliant prisms. Those of CsI_3 are black and almost opaque; those of $CsBrI_2$ dark reddish-brown by reflected and deep red by transmitted light; $CsBr_2I$ forms crystals of a bright cherry-red colour; while the crystals of CsClBrI, $CsBr_3$, and $CsClBr_2$ are tinted with various shades of orange. The compound $CsCl_2Br$ forms bright yellow crystals, the lightest coloured in the whole series. Two other possible salts of the series, $CsClI_2$ and $CsCl_3$ have not yet been obtained. The general method by which the above eight salts were prepared consisted in dissolving the haloid salt of cæsium employed in water, adding the requisite quantity of iodine or bromine, or leading a stream of chlorine through the solution, and cooling or evaporating to the crystallizing point. The salts are remarkably stable, they may all be preserved for any length of time in corked tubes or bottles. They form an isomorphous group, all crystallizing in the rhombic system. An important relation has been discovered between the crystallographical constants of the first five members of the series, those containing iodine. The ratio of two of the axes remains almost constant throughout the whole of the five, while the third varies with the molecular weight.

THE formation of salts of the nature above described, in which a compound such as cæsium chloride, which is usually considered as fully saturated, actually combines directly with two more atoms of a monad halogen element, is a most important and interesting fact considered in connection with the general subject of residual affinity. Cæsium, as is well known, is the most electro-positive element yet discovered, and that it should exhibit this phenomenon of residual affinity in so startling a manner is perhaps not surprising. Moreover, Johnson in the year 1877 obtained a tri-iodide of potassium, KI_3, and also in 1878 an analogous ammonium compound, NH_4I_3. The question of the constitution of such salts is a most complex one, but the balance of evidence, particularly that afforded by the crystallographical measurements, is decidedly in favour of considering them as double salts, and not as salts of trivalent cæsium. The acceptance of a possible trivalency of cæsium would of course be in direct antagonism to the teaching of the periodic generalization, and Prof. Mendeleeff himself considers the two extra atoms of iodine in potassium tri-iodide to be united much in the same manner as the water taken up by many salts upon crystallization.

THE additions to the Zoological Society's Gardens during the past week include a Grey Ichneumon (*Herpestes griseus* ♂) from India, presented by Mr. R. Meinertzhagen; a Lesser White-nosed Monkey (*Cercopithecus petaurista* ♀) from West Africa, deposited; two Snow Buntings (*Plectrophanes nivalis*), a Yellow Bunting (*Emberiza citrinella*), two Reed Buntings (*Emberiza schœniclus*), British, purchased; seven Coypus (*Myopotamus coypus*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

NEW STAR IN THE MILKY WAY.—The following circular was issued from the Royal Observatory, Edinburgh, 1892, February 2:—

Yesterday an anonymous post-card was received here bearing the following communication:—

"*Nova* in Auriga. In Milky Way, about two degrees south of χ Aurigæ, preceding 26 Aurigæ. Fifth magnitude, slightly brighter than χ."

At 6h. 8m. G.M.T. the star was easily found with an opera-glass. It was of a yellow tint, and of the sixth magnitude, being equal to 26 Aurigæ. Examined with a prism between the eye and the eye-piece of the 24-inch reflector, it was immediately seen to possess a spectrum very like that of the Nova of 1866. The C-line was intensely bright, a yellow line about D fairly visible; four bright lines or bands were conspicuous in the green; and, lastly, a bright line in the violet (probably $H\gamma$) was easily seen.

A telegraphic notice was sent to Greenwich in the afternoon, and later on, when the true nature of the object was recognized, to Kiel for general distribution. The star was photographed last night at Greenwich.

Its place for 1892·0 is 5h. 25m. 3s. + 30° 21'. It does not occur in the Bonn Maps. RALPH COPELAND.

OBSERVATIONS OF MARS.—*Publikationen des Astrophysikalischen Observatoriums zu Potsdam*, No. 28, contains the results of some observations of Mars, made by Dr. Lohse during the oppositions of 1883-84, 1886, and 1888. A series of measurements of the position-angle of the northern snow-cap has been made with the idea of accurately determining the direction of the polar axis of the planet. On February 8, 1884, the mean value obtained differed from Dr. Marth's ephemeris by 0°·216, being identical with that deduced from the corrected elements of the axis employed after 1884. In 1888 the distance of the centre of the northern snow-cap from the Pole was found to be 2°·39, and the mean correction of position-angle 0°·896. Reproductions of thirty-six sketches of Mars made in 1884 and 1886 accompany the paper. These show the principal markings, but not the canals and minute details seen by that perspicacious astronomer Schiaparelli, although the instrument used was an 11-inch refractor. The sketches are combined to form a map, on which the position determined with special accuracy is indicated.

At the conjunction of Mars and Jupiter, in October 1883, a determination was made of the comparative intensities of the actinic rays emitted by the two planets. A series of photographs of these bodies was taken with exposures varying from one to twelve seconds, and these were compared with a scale derived from a series taken with an artificial source of light at various distances, and another derived from Vega. The actinic intensity of Jupiter's southern hemisphere was found to be 2·176 times greater than that of the Martian surface, which, when the distances of the two planets from the sun are taken into account, gives 24·4 : 1 as the relative albedos. The ratio of the amount of light emitted by the southern hemisphere of Jupiter to that emitted by the northern hemisphere was incidentally found to be as 1·192 : 0·597.

SOLAR PROMINENCE PHOTOGRAPHY.—Some interesting recent results in the photography of solar prominences are stated by Prof G. E. Hale in the first number of *Astronomy and Astro-Physics*. In the first place, the line a little less refrangible than H, which Prof. Hale suggested was probably due to hydrogen, has been proved by M. Deslandres to have its origin in this element, by direct comparison with a Geissler tube. Prof. Young has also succeeded in photographing this line, which was first visually observed by him in 1880. With regard to the line at λ 3888·73, which forms a double with the hydrogen line α (λ 3889·14) of the stellar series, Prof. Young has not found the duplicity which very often distinguishes the Kenwood Observatory photographs. The hydrogen line α occurs on eighteen plates, but it is only certainly single on two of them. And it is a significant fact that in one of these cases only the upper part of the prominence lines was photographed, the light from a short distance above the sun's limb being cut off by a diaphragm. There seems little doubt that the line is a true one, and not a false appearance brought about by the reversal of the hydrogen line on account of which it is apparently duplicated. Its origin, however, is unknown. Prof. Hale thinks that both H and K in prominences are due to calcium, the absence of the strong line at λ 4226·3 being said to follow from its different appearance and behaviour in the arc, as compared with H and K. By a remarkable coincidence an eruption on July 9, 1891, was simultaneously photographed at Kenwood Observatory and visually observed by Herr Fènyi at Kalosca, Hungary. Copies are given of the drawing and photograph, and the general agreement in the form of the prominence is very striking.

RE-DISCOVERY OF BROOKS'S COMET (1890 II.).—A telegram from M. Perrotin to Prof. Krueger announces that Brooks's comet was found by M. Javelle, of Nice Observatory, on January 6 (*Astr. Nach.* 3074).

ELECTROTECHNICS.[1]

I BEG to thank you for the great honour you have done me in electing me your President for this year—a year which the need for a new complete index of this Society's Journal marks out as closing the second decade of its life; a year which sees the second thousand added to our roll of members; and a year which the Electrical Exhibition at the Crystal Palace distinguishes as inaugurating the second decade of electric lighting in Great Britain.

It has gradually become the custom for your incoming President to select, as the subject of his address, some investigation that has been engaging his attention. Following this custom, I purpose to-night to discuss an experiment in which, for the last nineteen years, I have taken some part—an experiment which, of all others, has been the one I have had most at heart—and that is, how best to train the young electrical engineer.

To some it may appear that I am treading on well-worn ground; but as the problem is one that is as yet by no means solved, and as it involves the preparation of the machine that is daily used alike by the dynamo constructor, the cable manufacturer, the central station engineer, and the lamp maker—viz. the human machine—the problem of fashioning this tool so that it may possess sharpness, an even temper, moral strength, and a mental grain capable of taking a high polish, is one that, in truth, deeply concerns every member, every associate, every student of this Society.

It is only fifteen years ago since I wrote from Japan to my old and valued master, Dr. Hirst, then the Principal of the Royal Naval College, Greenwich, asking whether he thought that the time had come for starting in this country a course of applied physics somewhat on the lines of that given at the Imperial College of Engineering in Japan. He replied that England was not yet ripe for such an innovation—an opinion which appeared to be borne out by the fact that after the authorities at University College, London, had in 1878 actually advertised for applications for a new chair of "Technology," they decided that it would be premature to take the responsibility of creating such a Professorship.

But matters were advancing more rapidly than was imagined by collegiate bodies; for in that same year this most valuable report on technical education which I hold in my hand was issued by a Committee of the Livery Companies of London, based on the opinions expressed by Sir W. (now Lord) Armstrong, Mr. G. C. T. Bartley, Colonel (now General) Donelly, Captain (now Sir Douglas) Galton, Prof. Huxley, and Mr. (now Sir H. Truman) Wood. And although it is twelve years since this book was published, I can recommend it to your notice, for it supplies most interesting reading even at the present day.

Under the guidance of three joint honorary secretaries, Mr. John Watney, Mr. Sawyer, and Mr. (now Sir Owen) Roberts, the City and Guilds of London Institute for the Advancement of Technical Education started, with a name that was very long, but in a way that was very modest, to develop a "Trades School" in accordance with this report. They borrowed some rooms, but for use in the evening only, from the Middle Class Schools in Cowper Street, Finsbury, and decided to erect ultimately a chemical laboratory in that neighbourhood.

But neither the building of a physical nor even of a mechanical laboratory formed any part of the scheme for this "Local Trades School." For at that time the teaching of the applications of physics to industry hardly existed, and certainly not its application to any electrical industry other than telegraphy. To make a start, however, in such teaching was most desirable, and therefore Dr. Wormell, the enlightened head master of the Cowper Street Schools, consented to give up the use of some rooms not merely during the evening, but also during the day, to enable Dr. Armstrong and myself to carry out our plan of fitting up students' laboratories with a small amount of apparatus kept permanently ready in position.

For the devotion of these rooms to the carrying out of this new experiment we must always feel grateful to Dr. Wormell, for it was necessarily accompanied by a reduction in the size of his school, and consequently by a pecuniary loss to himself.

The first laboratory course of the City and Guilds Institute was then advertised, and on January 9, 1880, three students presented themselves—a little boy, a gray-haired lame man, and a middle-aged workman with emphatic but hazy notions about the electric fluid.

In order to further utilize these rooms, the Institute sanctioned laboratory teaching during the day, and one of the cellars of the Cowper Street Schools was borrowed in order to fit up a gas-engine, coned shafting, and a transmission dynamometer, obtained out of the funds of the Institute; an A Gramme dynamo

[1] Inaugural Address of Prof. W. E. Ayrton, F.R.S., President of the Institution of Electrical Engineers, delivered on January 28, 1892.

lent by Mr. Sennett, then one of the students; and two arc light dynamos for transmission of power experiments, lent by the Anglo-American Brush Corporation, whose cordial interest in the work of the City and Guilds Institute has been marked throughout. And as these dynamos were used, not for electric lighting, but as laboratory instruments for educational purposes, England can claim to have been one of the first in the field of teaching electrotechnics.

Rapidly grew these electrotechnical classes; soon the temporary laboratories in Cowper Street were overcrowded, especially as applied mathematics and mechanics, under Prof. Perry, were added to the subjects taught; the £3000 which had been set aside for the building of this "Local Trades School" grew into £35,000, thanks to the combined donations of the Drapers' Company and of the Institute, and in 1881 was laid the foundation-stone of the present Finsbury College.

During the many years that Prof. Perry and I were linked together, the work of either was the work of both; but now I wish to take this opportunity of acknowledging my personal debt of gratitude for the fund of suggestion which he put forth regarding the teaching of science through its practical applications—the keynote of true technical education. The value of these suggestions you will fully appreciate, for they form the basis of those characteristic and attractive lectures familiar to so many of you who have been his pupils.

As we have seen, then, the present Finsbury College grew out of the "Local Trades School," and formed no part of the original scheme of the Institute. And it was because London was really in want of practical laboratory teaching about dynamos, motors, electric lamps, and engines, and because that want was supplied in a form suitable to the comprehension and to the pockets of workmen in the basement and cellars of the Cowper Street Schools, and last, but by no means least, because one of the Executive Committee of the Institute, Mr. Robins, strenuously exerted himself to further technical education in Finsbury, that the various electrical, physical, and mechanical laboratories now in Leonard Street, Finsbury, came into existence.

But the establishment of a Central Technical Institution "for training technical teachers, and providing instruction for advanced students in applied art and science," had been recommended in all the reports sent in to the Committee of the Livery Companies by the six authorities to whom I have referred. So that in the same year that the foundation stone of the Finsbury College was laid by the late Duke of Albany, that of the Central Technical Institution was laid by the Prince of Wales.

And, if you will allow me to say so, the success of the latter institution has been no less marked than that of the former, for, in spite of the rather stiff entrance examination, the number of students who attend all four of the departments at the Central Institution is more than threefold what it was five years ago. In fact, in the mechanical and electrical engineering departments there are already about as many students under instruction as class room and laboratory accommodation will admit. Hence this year will see a considerable increase in the amount of apparatus and machinery, as well as in the space devoted to dynamos and motors, in Exhibition Road.

While, on the one hand, the rapid growth of the work of the Guilds Institute is no little due to the fact that the latter end of this century has ushered in the electric age of the world; the electrical industry of our country, on the other hand, is no little indebted to the aid so generously given by our City Companies to the teaching of electrotechnics. For the students who during the last eleven years have, for an almost nominal fee, worked in the electrical laboratories at Cowper Street, at the Finsbury College, and at the Central Institution, number several thousands, and nearly every electrical works, every place giving electrotechnical instruction throughout this country, employs some of them.

The success which these students have thus achieved, through their own ability and exertions, is, I think, in no small measure due to the Institute having so wisely left the teaching it gave untrammelled by any outside examining body, so that it was possible for this teaching to be directed solely to the professional needs of the students, and to be modified from time to time as it seemed necessary.

My hearty thanks are indeed due to the Japanese Government and the City and Guilds Institute, my masters during the last nineteen years, for having left my colleagues and myself unfettered liberty to carry on this experiment of finding out better and better ways of teaching the applications of science to industry.

And there need be no fear that with this freedom the teaching will become stereotyped, and gradually cease to deal with the living science of the factory, for, being bound by no code, we are able to vary our methods, our experiments, and our apparatus, according to the continually changing conditions of the profession. In order that the Guilds Institute should fulfil its aim, it is absolutely necessary that its teaching should keep pace with industrial progress. Now, even if it were possible for outside examiners, with fixed scholastic notions, to aid in securing this result, would not their efforts be superfluous? for are there not *you*, the employers of labour, to ultimately decide whether the human tool we fashion is, or is not, adapted to your requirements?

Leaving now the consideration of the direct work of the City and Guilds Institute, including their extended system of technological examinations, at which last year 7322 candidates were examined in 53 different subjects at 245 different places in Great Britain and the colonies, the indirect results that have proceeded from the initiative of this Institute are even greater. For, while twelve years ago, education in applied science in this country was a tender little infant, requiring much watching and support, combined with constant encouragement, to-day Technical Education—with a capital T and a capital E, bear in mind—is a stalwart athlete, the strong man on the political platform, exercising the minds of county councillors, and actually regarded as of more importance than the vested interests of the publican.

Until quite recently it was the technical education of the young engineer that had to be considered; but now the problem has become a far wider one, for the education of the British workman is being vigorously pushed forward, and I think that it has become incumbent on you—the representatives of the electrical profession—to express your decided opinion as to what this education of the electrical artisan ought to be.

The technical education snowball set in motion twelve years ago by the City Companies has been rolling—nay, bounding forward—so swiftly during the last year or two that probably some of you have hardly followed it in its rapid growth, both in size and speed. £30,000 has been spent on the Polytechnic in the Borough Road; the Charity Commissioners have already endowed this school with an income of £2500 a year, and it is hoped that before the building is opened, this income will have been doubled. £50,000 has been already promised for the Battersea Polytechnic, the Charity Commissioners having also undertaken to provide this technical school with an income of £2500 a year as soon as the subscription reaches £60,000; and for the establishment of a polytechnic in the City, £50,000 has been set aside out of the funds of the Charity Commissioners, as well as a yearly grant of £5350. Finally, not to speak of polytechnics in North, South, East, and West London, Mr. Quintin Hogg has himself spent £100,000 on the Regent Street Polytechnic, while the Drapers' Company have alone given £55,000 to the technical department of the People's Palace at Stepney, and endowed it with an income of £7000 a year. And, most recently of all, the Goldsmiths' Company have put on one side nearly a quarter of a million sterling for the land, the buildings, and for an endowment of £5000 a year in perpetuity, for their Technical and Recreative Institute recently opened at New Cross.

The following table gives an idea of the sort of sums that are being spent on polytechnic education in London, but it does not profess to give the entire amounts that have been devoted to capital expenditure and yearly maintenance, even for the six polytechnics named in the table:—

Capital Expenditure.		Yearly Endowments.
Polytechnic, Borough Road.		
Already spent ...	£30,000	Charity Commissioners alone ... ... £2,500 (Endowment expected to be doubled before opening.)
Battersea Polytechnic.		
Already subscribed	£50,000	Charity Commissioners alone £2,500
City Polytechnic.		
Charity Commissioners alone to spend...	£50,000	Charity Commissioners alone £5,350

Regent Street Polytechnic.

Spent by Mr. Quintin Hogg £100,000	Charity Commissioners alone £3,500
Spent by Charity Commissioners 11,750	

People's Palace, Mile End Road.

Given by Drapers' Company alone ... £55,000	Draper'sCompany alone £7,000
Given by Charity Commissioners alone 6,750	Charity Commissioners alone 3,500

Technical and Recreative Institute, New Cross.

Given by Goldsmiths' Company £70,000	Goldsmiths' Company £5,000

(Representing a total expenditure of nearly £250,000.)

Other contributions to polytechnics in London by Charity Commissioners ... £6,000	Yearly endowments of CharityCommissioners to other technical institutions in London... ... ... £3,200

Totals from the above sources alone:

£379,500	£32,500

Large as are these sums, they are, however, even small compared with the amount raised by Mr. Goschen's beer and spirit tax, which it has been decided shall be used for the public benefit, and not for the benefit of the publican. The counties and county boroughs of England now receive nearly three-quarters of a million sterling per annum, of which the whole may be devoted to technical education. The majority of the counties and county boroughs propose to utilize this magnificent opportunity and devote to technical education the entire sum allocated to them, while the remainder use at least a part for this purpose. Middlesex and London, however, stand alone, and employ their whole yearly grant of £163,000 for the relief of the rates, on the plea that they consider that the City Companies are well able to look after the technical education of London.

Besides this spirit duty, 106 towns are levying rates in aid of technical education under the Technical Instruction Acts of 1889 and 1891, the number of these towns having increased by twenty in the last seven months, showing how rapidly is this desire for technical education spreading throughout Great Britain.

In addition to the sums contributed for technical education by the City Companies, collegiate bodies, and private persons who have the practical education of the nation at heart, the following represent, as far as I have been able to ascertain, the amounts that it has been already decided shall be *actually* spent, *yearly*, on technical education in England alone, exclusive of Scotland, Ireland, and Wales:—

Received from the Customs and Excise duties ...	£500,000
" " Rates	18,046
Given by the Charity Commissioners	20,550
	£538,596

The yearly amount that will be actually raised under the Technical Instruction Acts will be far larger than the £18,046 stated above, for this represents only the sum of the amounts raised in the very few towns who have already made returns.

Hence the total sum to be spent in England alone on so-called technical education amounts to certainly over £600,000 per annum.

As the teaching of electrical technology has been started, in some form or other, in nearly every important town in Great Britain, there is no occasion for me to advocate, as I did in this room ten years ago, that a student of electrical engineering should have an education in applied science; but what I desire to most strongly urge on you to-night is, that it is your bounden duty to see that some portion of the vast sum that is about to be spent on the education of the people is used to give such a training to your workmen as shall really benefit your industry. For otherwise there is a great fear that most of the money devoted to electrical teaching will either be frittered away on the natural loadstone, rubbed amber order of instruction so dear to the hearts of the school-men, or on semi-popular lectures describing in a bewildering sketchy fashion the whole vast field of electrical engineering.

The workmen you employ are of two classes. In the one class is the man who is all day long, say, stamping out iron disks for armature cores, and the boy who, say, feeds the screw-making machine with its proper meals of brass rod. For such work no technical education is necessary; the workers are mere adjuncts to the machines, to be dispensed with as the machines become more and more perfect. Hence, unless the machine-minder has the ambition and the ability to rise to some less mechanical occupation, his activity, if any be left him after a hard day's work, had probably better be spent in effort of a lighter and more recreative character than would alone be necessary to make him a higher class of artisan.

For him the polytechnic variety course of instruction is an inestimable blessing, for he can do a little type-writing, learn violin-playing and modelling in clay, attend an ambulance class, recite a poem, and devote the remainder of his leisure to the piano, botany, sanitary science, reading books and learning how to keep them.

His general interests will be roused, the human side of his nature developed, and during the evening at any rate he may forget that he is the slave of the Gramme ring, or the slave of the electric lamp.

No wonder, then, that within two months of the opening of the Goldsmiths' Institute at New Cross 4000 members were enrolled.

But your workmen of the other class must, or at any rate ought to, think. Take, for example, the man engaged in wiring houses, whose work is continually changing, and offering small problems to be solved. Here, common sense—or uncommon sense, if you prefer it—is of great value, and the work, to be good, *must* be done by a man with a knowledge of principles, and not by a mere machine-minder.

Many joints—bad joints—wires laid in cement under mosaic, which cannot be replaced except at vast expense, even although the insulation has rotted away—parqueterie floors nailed to insulated wire—switchboards screwed on to damp walls—lamp-holders that only make contact when the lamps are twisted askew—high-class insulated mains terminating in snake-like coils of flexible wire running against metal in shop windows, under shop fronts—heavy Oriental metal lamps hanging from lightly insulated cord—all this would be avoided, if the workmen had been taught to use their brains as well as their hands.

Now, do you think that the teaching necessary for this purpose is likely to be given at the ordinary English polytechnic school? In the case of the Goldsmiths' Institute the electrotechnical department has been put under the charge of Messrs. Dykes and Thornton, two diploma students of the Central Institution; and the fact that these men are, in addition, both employed in Messrs. Siemens's works at Charlton leads one to hope that their teaching, at any rate, will breathe the spirit of the factory. And therefore, if ample funds be forthcoming for keeping the apparatus at New Cross always up to date, so that the meters, the models, the dynamos—not merely now at the start, but three years hence, six years hence—are truly representative of the industry, there will be a fair prospect that the electrical department of the Goldsmiths' Institute, although but a fraction of the whole undertaking, may really benefit the electrical workmen in the East End of London.

But my colleagues and I view with considerable apprehension the way in which the present wide demand for teachers in technical schools is being supplied. Several of our own students, for example, tempted by the comparatively high remuneration that is offered, have become teachers in technical schools immediately on leaving the Central Institution. In many respects they are undoubtedly well qualified; but if they had first spent some time in works before attempting to teach technical subjects, they would have better understood the wants of the persons whom they have undertaken to instruct.

No greater mistake can be made than to think that a student who has distinguished himself at a technical college can dispense with the training of the factory, unless it be the opposite mistake of imagining that the factory training is equivalent to or even something better than that given at a modern school of engineering.

It is the province of the manufacturer to turn out apparatus and machinery as quickly, cheaply, and as well made as is possible; it is the province of the technical teacher to prepare the human tool for subsequent grinding and polishing in the works.

And this necessity for the teacher having himself passed through the shops has especial weight when we are dealing with the technical instruction of workmen, for in such a case there are three requirements absolutely necessary: first, knowing how to teach; second, possessing a fair knowledge of scientific principles; and thirdly—and this is, perhaps, the most important of all—knowing exactly what it is that the particular workman ought to learn in order to help him in his particular trade.

Schoolmasters may have the first two requisites, and so may do valuable work in connection with the variety teaching at a polytechnic; but they are not in touch with the workshop, and therefore, no matter what may be their scholastic attainments, no matter what the extent of their experience in training the young, they are not the persons to give the real technical education to workmen.

In addition, then, to the polytechnics, we must have special schools for special industries, where workmen are taught the application of science to their special trades; and everything taught in such a school must be taught as bearing on the particular industry which the school is intended to benefit. A teacher of physics, for instance, must remember that he is not training physicists, but workmen whose use of physical principles will be bounded by their application to their special trade. For the great danger of such teachers is that, carried away with enthusiasm for their own subject, they will not subordinate it properly to the end in view, viz. helping the workman to know what will be useful to him in his work.

Indeed, as Prof. Huxley pointed out in his original report to the Livery Companies' Committee, "Success in any form of practical life is not an affair of mere knowledge. Even in the learned professions, knowledge *per se* is of less consequence than people are apt to suppose. . . . A system of technical education may be so arranged as to help the scholar to use his intelligence, to acquire a fair store of elementary knowledge which shall be thorough as far as it goes, and to learn to employ his hands, while leaving him fresh, vigorous, and content, and such a system will render an invaluable service to all those who come under its influence.

"But if, on the other hand, education tends to the encouragement of bookishness, if it sets the goal of youthful ambition, not in knowing, but in being able to pass an examination, especially if it fosters the delusion that brain work is, in itself, a nobler or more respectable kind of occupation than handiwork, and leads to the sacrifice of health and strength in the pursuit of mere learning, then such a system may d› incalculable harm, and lead to the rapid ruin of the industries it is intended to serve."

And I venture to think that not merely at technical schools for workmen, but at technical colleges for engineers, it should be ever remembered that the main object of the training is not the cultivation of mental gymnastics, but to enable the student to acquire knowledge and habits which shall be professionally useful to him in after life.

"Useful learning usefully taught" would be no bad motto for technical institutions, seeing that those who favour the compulsory teaching of Greek are apparently willing to accept the converse as the motto for the University. For example, Mr. Butcher, in his address delivered at the end of last session at University College, Bangor, said: "We may claim it as a distinction that in the seats of academic learning little or nothing useful is taught"; and in an article in last month's *Fortnightly Review*, congratulating Cambridge on its recent victory over the *barbarian*, Mr. Bury says quite candidly, "Greek is useless; but its uselessness is the very strongest reason for its being a compulsory subject in the University course." And he adds, in italics, "*For the true function of a University is the teaching of useless learning.*"

A few of the County Councils have realized that the real teaching of the application of science to a special industry, which is what the British workman is so much in need of, cannot be given, as well as a host of other subjects, out of limited funds. For example, Bedfordshire has decided to spend its grant of £4343 mainly on agriculture, market gardening, the straw trade, domestic economy, and industries for women; Cambridgeshire and Cheshire devote themselves largely to the teaching of agricultural pursuits.

But other places aim at issuing vast comprehensive programmes and turning out yearly a mighty array of students, knowing, it may be, the something of everything, but who certainly will not know the everything of something. For example, the Holland division of Lincolnshire has decided, out of only £2000 a year, to make grants for dairy schools, University extension and art schools, agricultural science, domestic economy, mechanics, commercial subjects, and ambulance teaching; while Bootle, with a yearly expenditure of only the same amount, maintains classes in five commercial subjects, in sixteen science and art subjects, in cookery, wood-working tools, as well as four courses of University extension lectures.

Because a certain building in Regent Street famed for its ghost and its diving bell was years ago named "The Polytechnic," the majority of the new technical institutions which are being established in London at such vast cost are also called "Polytechnics," and will, I fear, give only an English polytechnic course. Now, such recreative education, although admirable for those who seek relief from work in the use of their minds, is not generally sufficient for those of your workmen who use their minds in their daily occupation.

It ought, then, to be thoroughly recognized that there is an entirely new problem to be solved, and that the solution of this problem, in so far as it has been worked out at the Finsbury College and at other places giving practical teaching in the evening, must, in the language of the mathematician, be regarded simply as "the singular solution," and not the general solution, of the problem of technically educating the British workman.

Let us gratefully accept the English polytechnics, for they will undoubtedly confer benefit on our country, and all credit be to those who have so generously established them. But do not let us be misled by the similarity between their generic name and that of the German "polytechnicum" into fancying that the recreative courses of the one are equivalent to the serious education given by the other.

Like Oliver Twist, let us ask for more; for, on behalf of the large number of minds already employed in the electrical industry, and on behalf of the still larger number that will in the future be so employed, it is our duty to secure that ample provision be made in this country for the practical teaching of electrotechnics on a scale comparable with that afforded in the technical high schools of Germany and the institutes of technology of the United States.

On the screen you see projected a photograph of the *façade* of the Technical High School at Charlottenburg (Berlin), which appears extensive and grand; and yet, as you will see from the next photograph, it was only a small portion of the whole building that you were looking at on the first photograph. This is but one of the many technical high schools in different towns of Germany, and yet *it covers an area more than five times as large as that occupied by the Central Technical Institution in Exhibition Road, London, cost four times as much to erect, and has more than four times as much spent on its yearly maintenance.*

The next photograph shows a building devoted wholly to the training of electrical engineers, being that of the Electrotechnical Institution Montefiore at Liége, which Prof. Gerard kindly took me over this last summer, and which has since been opened. When I tell you that there are rooms for small direct-current dynamos, separate rooms for large direct-current dynamos, separate rooms for alternators, and that every three students have a separate little laboratory, with the necessary measuring instruments, all to themselves, your educational mouths will water, as mine did.

We now cross the Atlantic to the Massachusetts Institute of Technology, Boston, which, as you see, consists of several distinct buildings, the centre one being that which contains the electrical laboratories. The dynamo room now seen on the screen has many small and large dynamos in it, and yet there is ample room to walk about, for this dynamo room occupies a space many times as large as that devoted to dynamos at the Central Technical Institution of London.

Prof. Cross was so good as to mention in a letter that was shown me some two years ago, that several of the devices that had been worked out for the electrical laboratories of the City and Guilds Institute had been reproduced at Massachusetts; but there is one device that Prof. Cross has succeeded in working out, and which I should be most glad to see copied by the City and Guilds Institute, and that is, having one assistant for every five students working in the physical laboratories.

Franklin Hall, presided over by Prof. Nichols, is devoted solely to the department of pure and applied physics at the Cornell University, Ithaca. You see how large this four-storied building must be, for look how small the four-wheeled waggon standing in front of it appears.

The next three photographs show some of the provisions made for teaching electrotechnics in Franklin Hall; the electrical laboratory, under Prof. Moler; and the dynamo room, under Prof. Ryan, whose analyses of alternate-current curves are well known to you all.

I might show you photographs of the electrical laboratories in Prof. Weber's new building for physics at Zürich, on which £100,000 has been already expended. In fact, my choice of magnificent Continental and American laboratories has been so great that I have hardly known which to select as specimens.

But there is one thing I cannot show you—and it must remain for the exercise of your influence as representatives of the electrical profession to make that possible—the British electrotechnical laboratories for education and research which are truly worthy of London, the capital of the world.

The training of such students as those at the Central Institution must, of course, differ essentially from that of the electrical artisan, not because we, or the students, expect that on entering a factory at the conclusion of their college course they will start, as a rule, much above the bottom of the ladder, but because they hope in time to be able to mount higher.

They are therefore taught, not merely to construct meters and motors, use dynamos and engines, build a chimney and lay a street main, but, as they are not to spend all their lives wiring houses or watching a central station voltmeter, they are well practised in calculating and designing, and they further obtain sufficient acquaintance with the methods of attacking new problems not to be daunted when they meet with them in after life.

But so strong is becoming our belief in the value of science to the manufacturer, so anti-classical are some of us growing, that there is great risk that the literary side of the education of an electrical engineer will soon be wholly neglected. Now, important as it no doubt is for him to be quite at home with electrical apparatus and machinery, it is no less important, if he is to take advantage quickly of the progress made abroad, that he should be able to read a German or a French newspaper. I do not merely mean that with a grammar and dictionary, and plenty of leisure, he should be able to translate the newspaper, sentence by sentence, like a schoolboy preparing to-morrow's lesson, but that he should have the power to glance down the columns, gather the gist of the articles, and quickly see whether there be anything new that especially concerns him.

How many electricians are there in this country who can, for example, take up the *Zeitschrift für Instrumentenkunde* or the *Electrotechnische Zeitschrift*, and look through their pages as they do those of the *Electrician*, *Electrical Review*, and the *Electrical Engineer*, during breakfast on Friday morning? There are, I know, a few—I wish I were one of them.

And yet examples are not wanting of the scientific isolation that is caused by not possessing that familiarity with foreign languages which is a characteristic of diplomatists and hotel waiters. Take, for instance, the fact that, whereas manganin was manufactured on a commercial scale in Germany, and German resistance coils have for the last three years been constructed of this material with a temperature coefficient of nearly zero, the very existence of this alloy was unknown to many English electrical instrument makers a few weeks ago; and even now most of them are still unacquainted with the composition of manganin, and its peculiar properties, as well as with the results of the extensive and striking experiments that have been carried out at the Reichsanstalt at Charlottenburg on the temperature coefficient and specific resistance of all sorts of manganin-copper-zinc-nickel-iron alloys.

This Physikalisch-Technischen Reichsanstalt, I may mention, is an establishment totally distinct from the Technical High School in Charlottenburg, some photographs of which I showed you this evening. The Reichsanstalt is not an institution with students, but a vast series of Imperial laboratories, presided over by Prof. von Helmholtz, solely used for carrying out researches in pure and technical physics. The investigations are conducted under the direction of Dr. Loewenherz, aided by 46 assistants.

We have no establishment in Great Britain at all comparable with this Reichsanstalt. The original work turned out there in electro-technics alone is considerable. Here are some of the published accounts of researches immediately bearing on your profession which Dr. St. Lindeck has been so kind as to send me: "Hardening Steel Magnets," "Standard Resistance Coils for Large Currents," "Tests of Commercial Ammeters and Voltmeters," "Mercury Standard of Resistance," "Photometric Investigations," "Compensation Apparatus for Use in P.D. Measurements," "Alloys for Resistance Coils," and so on.

Surely it is part of the technical education of the electrical engineer to be taught how to read such pamphlets as these with comparative ease?

A working knowledge of French and German can be obtained without the necessity of learning to express oneself fluently in epigrammatic French, or to imitate with facility the word-building of a native German; and with such a working knowledge the average technical student may rest content. But as regards his own language he should aim at something higher, and therefore the electrical engineering students of our country should be, I urge, practised in writing—yes, and also speaking—vigorous English.

Only the other day, Prof. Nichols, of the Cornell University, was deploring with me the rarity of finding a student of electrotechnics who could write a decent report. The experimental methods employed in the student's investigation might have been good, the mathematical analysis suitable, and the calculations exact; but the description of the apparatus and of the results obtained would be scattered pell-mell over the paper, as if the writer were quite ignorant of the fact that the style in which a dish is served up is nearly as important as the goodness of its ingredients.

Why do you suppose that Huxley's portrait has nearly as much prominence given it in the photographer's window as that of a duke or a ballet dancer? Quite as much because he knows how to express himself in terse and forcible English as on account of his wide scientific knowledge; because even when writing about dry bones the flow of his language clothes them with rounded forms.

But, you will ask, how are we to find the time for all this linguistic and literary polish? has the electrical student of to-day so many spare hours that fresh subjects of study must be sought for to fill up his leisure moments?

At present much time has to be wasted at technical and other colleges teaching students sixteen years or older elementary mathematics and science, which ought to have been mastered before that age. When the education of childhood is improved, when the higher education of women is properly carried out, there will be no need for male experts to trouble about general training, for then children will spend less time at school and learn more; boys and girls will, as a matter of course, acquire the foundation of modern languages and general education; and students at a college will be able to devote their whole time to the special training—scientific, manual, linguistic, and literary—which pertains to the particular profession which their special tastes will generally have led them to select before the age of sixteen.

And just as methods of teaching applied science have been developed during the past few years, so I look forward to the growth of new methods of teaching what may be called applied literature. For it seems to me that there is a want of breadth in the view that because the study of Greek verse would be unprofitable for a student of electrotechnics, and because he has neither the taste nor the time to enter into the intricacies of etymology and grammar, therefore the study of modern languages and literature, even as directly applicable to his profession, should form no part of his regular training.

As well might it be thought (and I am sorry to say this view is not yet quite exploded) that because a student has neither the taste nor the time for the study of abstract mathematics, therefore he should be debarred from all work in a physical laboratory. Well, if it be generally accepted that although a young electrical engineer has no chance of becoming a Cayley or a Maxwell, still he ought to be taught such portions of mathematics and physics as will be directly useful to him in his profession, why should the certainty that he will neither become a Jebb nor a Dickens lead us to tolerate an inability on his part to speak fluently and write tersely his own language, surpassed only by his entire ignorance of every other?

Habits of scientific thought are highly necessary for electrical students; to be masters of their own language, and to know something of one or two others, are, I venture to think, no less so; but the main result to be achieved, the main object to be aimed at, with every system of education, is moral thoroughness.

For until every workman, foreman, engineer, and manufacturer feels regret and pain at seeing work inefficiently performed, our national system of education will be incomplete.

All the labour now expended in watching work in progress, and in testing it when completed to see that it has not been scamped, is so much withdrawn from the real business of production. Every rise, therefore, in the standard of thoroughness of a community means the saving of waste labour. But far greater than this will be the actual increase in the productive power when each gives his best endeavours to his share of the world's work. And greatest of all will be the gain in the nation's happiness, since he who works with his whole soul knows no drudgery.

The lesson to be taught is no new one—it was set many centuries ago; and hundreds of thousands a year will be well spent if the County Councils can succeed in bringing home to the hearts of us all this—"Whatsoever thy hand findeth to do, do it with thy might."

PHOTOGRAPHY AS A BRANCH OF TECHNOLOGY.[1]

THE invitation conveyed to me by your Council, to assist in promoting a scheme of photographic technical education of a more complete character than that provided by the elementary schools, is in such complete accord with the principles which I have always held, and which I have occasionally promulgated through other channels, that I felt it an almost imperative duty to respond to the invitation in spite of the numerous other claims upon my time. For I believe that if the Photographic Society will throw itself with zeal into some well-organized scheme in this direction a great benefit will be conferred upon the cause of technical education in this country. I will even go so far as to express the belief that a work of national importance may be accomplished.

It may perhaps appear as preposterous to dwell upon the importance of photography before the members of this Society as it would be for a merchant to address the Chamber of Commerce on the importance of trade, or for a financier to lecture to an Institute of Bankers on the importance of banking. Nevertheless, it is a common experience that those who are actively engaged in the prosecution of some special kind of work often take a narrow view of their own labours; they have no time to take a bird's-eye view of the whole subject, and an independent outsider may sometimes do good service by gathering up the odds and ends of scattered observations and fitting them into their right positions in the general plan. If any justification is required from me for addressing a Society composed so largely of photographic experts, I need only plead that as a teacher of technical chemistry I have felt it necessary to give full recognition to the claims of photography as an important branch of technology. It can no longer be ignored that photography has penetrated the arts and sciences to an extent that has raised it to an exalted position among technical subjects, and as such it has not yet received its proper recognition in this country. From the very dawn of its discovery the importance of its applications was foreseen, although it is only in our own time that the realization of this importance is being witnessed. We need not commit ourselves to the extravagance of Paul Delaroche, the artist, who, during the excitement caused by the revelation of the Daguerreotype process, is said to have declared: "Painting is dead from this day!" The art of the painter has not been killed, but it may fairly be claimed that it has been aided by photography; the art of the engraver has been revolutionized by its means. The prophetic utterance of a writer in the *Edinburgh Review* for January 1843 has been fulfilled:—

"The art of Photography or Photogeny, as it has been called, is indeed as great a step in the fine arts as the steam-engine was in the mechanical arts; and we have no doubt that when its materials have became more sensitive, and its processes more certain, it will take the highest rank among the inventions of the present age."

All who are familiar with modern photographic methods will admit the truth of this prediction; the materials have been rendered more sensitive and the processes more certain. The sensitiveness has been increased to a degree that would probably astonish the writer of the passage quoted, and the certainty of the processes is such that the amateur photographer exists by thousands. It is perhaps this last circumstance which is responsible for the identification of photography in the public mind with the taking of portraits and landscapes. These are no doubt very important applications of the subject, but photography is not synonymous with portraiture and the taking of scenery; if we allow this view of the subject to prevail, it cannot but have the effect of narrowing down the general estimate of its importance, and of thus injuring its claim to take high rank among technical subjects. We are here, I imagine, to proclaim the far-reaching importance of our subject. Everyone knows with what beautiful effect the photographer can reproduce a portrait or a piece of scenery, but what is not so generally known to the public at large is the enormous service that photography has rendered to other branches of science. If dwell therefore upon this application of the subject, it is not for the purpose of depreciating its application to art, but rather for the purpose of exalting both aspects.

The modern dry plate has insinuated itself into every branch of practical science; whenever a phenomenon of a temporary character has to be registered with absolute accuracy—where the human eye fails, owing to the faintness of the object, or the rapidity with which the phenomenon occurs, there the aid of the dry plate is invoked. The application of photography to astronomy has, as is well known, relieved the eye of the astronomer and curtailed the work of the observatory to an extent bordering on the marvellous. A faint nebula, which by eye observation may take many years of wearying labour to represent in the form of a drawing, in the course of a few hours impresses its image in all its fineness of detail on the photographic plate—a memorial for future ages of the true form of the nebula at the time of its being photographed. Stars which appear as points of lights in the telescope are shown by the photographic plate to be small nebulæ, and stars and nebulæ which have altogether eluded the most powerful telescopic search impress themselves on the sensitive film. All this and much more in the same direction is such familiar knowledge now that it is only necessary to mention the facts, nor need I remind you how the photographic plate is being utilized for the photo-astrographic survey of the heavens, and in astronomical spectroscopy for the permanent registration of the solar spectrum and the spectra of the stars. The "Draper Memorial" is one of the latest examples of the utility of photography in the observatory; it is no exaggeration to say that one of the grandest problems of modern science—the question of stellar evolution—will be rendered capable of scientific discussion by this application of the gelatino-bromide film. The modern astronomical observatory is in fact equipped for photographic work quite as much as for observational work, and the photographer has become as necessary as the observer.

In physics and in chemistry also the photographic plate has been added to the weapons of research. Here it has been used to record phenomena which occur with such rapidity as to elude visual perception. What would the Edinburgh Reviewer of 1843 have thought of the possibility of photographing a soap film in the act of breaking, or a liquid drop in the act of falling? Yet, as you all know, Lord Rayleigh and Mr. Boys have succeeded in doing this. Or take again the application of the sensitive plate to the elucidation of the phenomena of gaseous explosions by Prof. Oettingen who, by using a rapidly rotating dry plate, was enabled to show the intermittent character of the flash produced by the explosion of hydrogen and oxygen. Profs. Liveing and Dewar have also succeeding in photographing the spectrum of a mixture of exploding gases. In spectrum analysis, in fact, the services which have been rendered by photography cannot be over-estimated. The astronomer, the physicist, and the chemist must have for reference complete and accurate charts of the spectra of the chemical elements. The early maps of Bunsen and Kirchoff, and the splendid "Spectre Normale" of Ångström were drawn by eye observation after years of laborious work, and with injury to the eyesight of the observers. These maps are now produced by photography without any tax upon the eyesight, and with an amount of detail that renders the early maps—executed with such painful labour—but mere skeletons as compared with their photographic representatives. The spectra can moreover be compared far more readily and with much greater accuracy by the photographic method. The method of eliminating the lines in the spectrum of one element, due to the presence of a trace of some other element as an impurity, which we owe to Prof. Norman Lockyer,

[1] An Address to the Photographic Society on February 2, by Prof. R. Meldola, F.R.S.

has only been rendered possible by photography. If the residual lines common to several elements, and which cannot be traced by this means to any known element, should lead to the discovery of new elements or to the resolution of known elements into simpler forms of matter, the credit must be given to the photographic method.

But it will be safer to confine ourselves to what photography has actually done for science than to attempt to enter the regions of speculation. The case to be made out is such a good one that there is no need to draw upon the imagination. Thus, again in the region of spectroscopy, the relationship between the constitutions of chemical compounds and their power of absorbing certain definite light waves, as investigated by Prof. W. N. Hartley, may be said to have been discovered by means of photography, because the absorption is, in the case of colourless liquids, exerted beyond the limits of the visible spectrum. In meteorology the photographic plate has also been of the greatest service, and a British Association Committee has been formed for the purpose of stimulating work in this direction. Most of those present are, no doubt, familiar with the more striking results achieved by meteorological photographers. The fleeting forms of clouds can be registered with absolute fidelity, and by an ingenious arrangement of electrically connected cameras the height and rate of motion of clouds has recently been determined by the aid of photography. The character of the electric discharge in the laboratory has been studied photographically by Mr. Shelford Bidwell and by Profs. Oliver Lodge and C. V. Boys, and the large-scale discharge of the lightning flash has been made to impress itself on the photographic plate. The results are known to all; the conventional zigzag "fork" appears to have no existence in nature. The destructive effects of wind storms on buildings can also be studied in photographs with an amount of accurate detail that it would be impossible to represent by any other method; and I am informed by Mr. G. J. Symons that important conclusions concerning the nature of the atmospheric movement have been arrived at by the examination of such photographs.

Passing on to other applications of photography, it is obvious that in geographical and ethnological exploration the camera has become an essential part of the traveller's equipment. In geology again the aid of the photographer has been called in, and with such good results that a British Association Committee has been called into existence, and has been doing excellent work in collecting and registering geological photographs during the last two or three years. In these photographs sections are recorded with a fidelity which it would be impossible to equal except by laborious sketching. Where time is an object, as in the case of sections only temporarily exposed, the camera is invaluable. Moreover, the value of such photographs will increase with time in the same way and for the same reason as photographs of the starry heavens. For while the latter, taken at the time of the present celestial survey, will, by comparison with photographs taken in the far distant future, reveal relative movements among the stars, the geological photographs of the present period will by future comparison with the localities registered furnish incontestable evidence of the slow course of geological change.

In biology photography has been utilized with great advantage, and will no doubt become of still greater service in the future. There is no reason why the dry plate, which has already largely superseded the eye in astronomy, should not also relieve the eye of the microscopist. Many biological works have been illustrated with great success by means of photomicrography, and even in purely systematic works, such, *e.g.*, as Marshall and De Nicéville's "Butterflies of India," photographic illustration has been adopted with success. In studying microscopic forms of life, where an evanescent phase of life-history may be full of profound significance, the photographic plate might well replace the eye in those cases where prolonged and fatiguing observation has hitherto been found necessary. The fleeting phases of expression, of such importance in comparative psychology, have been caught and fixed on the photographic plate with a natural fidelity that it would have been impossible to attain without snch aid. Mr. Darwin's work on "The Expression of the Emotions" was, as you are aware, illustrated by photography even before the dry plate had been worked up to its present exalted degree of sensitiveness.

The application of photography to the analysis of the movements of animals has been made familiar through the remarkable photographs which Mr. Muybridge has on many occasions brought under our notice in this country. Among other results recently achieved, I need only refer to those wonderful pictures of animals in motion, taken by Messrs. Marey and Anschütz. Such results as these are not only interesting illustrations of the high state of perfection to which modern photography has been developed, but they are of the highest value in elucidating the mechanism of animal movement, and of the flight of birds. The introduction of photography into this branch of animal mechanics has led to a complete revision of pre-existing conventional notions, and the indirect effect of such photographic analysis of the phases of motion on the work of the artist is of an importance that cannot be over-estimated.[1]

In the department of anthropology photography has served for the faithful registration of race types, and Mr. Francis Galton's method of composite portraiture is familiar to all. In his recent studies of "finger marks" in connection with heredity, Mr. Galton has also found it indispensable to work from photographic enlargements.

This imperfect sketch of the scientific applications of photography might well be followed by a much more extended list of its achievements in the domain of art. But I do not feel myself justified in taking up more time in telling you what you already know, and there are no doubt many present who are far more competent to deal with this aspect of the subject than I am. I cannot help thinking, however, that it would materially help the cause of technical instruction in the desired direction if some competent authority among you were to draw up a complete statement of the benefits which have accrued to art, both abstract and applied, by the introduction of photographic and photo-mechanical methods.[2]

To all who are interested in the advancement of art and of science, photography appeals, therefore, as a branch of technology of the first order of importance; in saying that it appeals to art and to science for such recognition, it is evident that it appeals to the nation at large. Even to the "pure scientist," who is supposed to lose interest in a discovery as soon as it becomes practical, *i.e.* commercial, this subject appeals for support, for from the study of the photographic processes themselves many important contributions to physics and chemistry have been made, and still greater results may be expected to follow from the investigations of scientific men in this direction. From its purely practical side the claim of photography to be considered as a branch of technology will receive additional support when it is remembered how many distinct branches of manufacture it draws upon, or has, indeeed, actually called into existence. Consider how it is dependent on the optician for the manufacture of lenses; consider, again, the special branch of cabinet-making and joinery which it has created in order to supply cameras and other instruments; remember, also, the boon which photography has conferred upon the chemical manufacturer by the demand for fine chemicals which it has created. Neither must it be forgotten that a new and by no means unimportant development in the manufacture of paper, gelatine, and albumen has arisen through the introduction of photography.

From every point of view, therefore, photography claims to be placed on the same basis as other branches of technology. The Photographic Society, I am happy to see, fully recognizes this in the recent action which it has taken, and which is expressed in the report of the Affiliation Committee. I consider this an excellent move in the right direction. But it is easy enough for the Society to recognize the technical importance of its own subject; the difficulty is to move public opinion, and to convince the nation that we are behind other countries in this respect. The first step is to draw up and circulate widely an account of what is being done for photographic technical instruction on the Continent. I had intended when first invited to lecture here, to offer some such statement, but I was glad to read in a recent number of your *Journal* that this task had been undertaken by Mr. Warnerke, and I hope that some means will be taken to bring his report under the notice of those interested in technical education. It is clear from what has already been attempted by this Society, and from the opinions which have been expressed on all sides by those whose voices carry the weight of authority, that nothing short of a Photographic Institute will meet the requirements of the case. This I most

[1] Prof. du Bois-Reymond deals with this in the address referred to. Some of Prof. Marey's recent results are described in NATURE, vol. xlv. p. 228.

[2] Since the above was written Prof. E. du Bois-Reymond's address to the Royal Academy of Sciences of Berlin on the "Relation of Natural Science to Art," has appeared in NATURE, vol. xlv. pp. 200 and 224.

earnestly hope will be the end and aim of every movement made by the Society. In the Cantor Lectures, which I had the honour of delivering before the Society of Arts in the spring of last year, I alluded to the absence of such an establishment in this country as "remarkable"; before this Society I am tempted to express myself more strongly, and to stigmatize its absence as a national disgrace.

Of course we all have more or less distinct ideas of what the functions of such an Institute would be. It is premature as yet to speak of the details of an institution which exists only in our aspirations. But whatever may be the final outcome of the movement which has been started, the whole duty of such an institution might be summarized in the statement that its work would consist in spreading a knowledge of all that is known concerning photography, and in investigating that which is unknown. In other words, its duties would be, as in the case of kindred institutions, teaching and investigating. Without wishing in any way to intrude my opinions into the deliberations of your Council, I thought that I might with advantage avail myself of the present opportunity of submitting my own views with respect to this question of technical education in photography. In giving expression to these views I have in mind the consideration that the remarks which I may apply to our special subject apply to many other related technical subjects, and that the course which may be adopted in the starting of such an Institute as that which we all wish to see come into existence, may have a wide and important influence on existing notions concerning the whole question of technical education.

In the first place, then, let me express the hope that any action taken by this Society in the direction of photographic technology, will be of the highest possible character. This may appear to you quite an unnecessary caution, but it involves a question of principle which it is very important to ventilate. After many years of apathy in this country, and after experiencing the inevitable consequence that we were being beaten in many branches of applied science by our Continental competitors, we underwent a few years ago a kind of revival in technical education. One outcome of this agitation was the foundation by the City and Guilds of London of that Institute in whose service I have the honour of being employed. It is not for me to dwell upon the results which have flowed from the inauguration of that Institute, but it is no exaggeration to say that the wave of public opinion which raised it into existence is still surging throughout the country. The last decade has witnessed the rapid multiplication of technical classes and colleges, the foundation of technical associations, the growth of polytechnics, and last of all, the diversion by the Government of the funds derived from the beer and spirit duty in the direction of technical education. The result of all this is that the means of technical education are being spread broadcast throughout the land.

Now it is one of our national characteristics that when we once wake up to the circumstance that we are behind other countries in any matter affecting our industries—or, I might say, when we have this unpleasant truth brought home to us by the superior workmanship or lower prices of our competitors—we are apt to seek remedial measures to recover our lost ground by what might be called indiscriminate and impulsive rushes. I am afraid that the technical education movement has, to some extent, been of this impulsive character. I am not going to be rash enough here to attempt to lay down any precise definition of what is meant by technical education; but a few months ago, the Duke of Devonshire, then Lord Hartington, made a speech at the opening of the Storey Institute, at Lancaster, in the course of which he said that technical education was not the teaching of any particular trade or handicraft, but rather the scientific principles underlying the trade or handicraft. I think this fairly represents the opinions of those who have considered the subject, and I hope that this definition will be borne in mind in any movement which this Society may inaugurate.

If now we review the situation, it will appear that the general spread of this educational movement may be taken as an indication that we intend to give battle to our competitors, and that we look to technical education to enable us to carry on the industrial campaign. So far so good; but our competitors, be it remembered, have been actively carrying on this branch of education during our long years of apathy. We have taken up our weapons rather tardily, and, as I just said, somewhat impulsively, and if we hope for success it behoves us to examine these weapons critically, in order to make sure that we are fighting on equal terms. In other words, are we adopting the best methods of technical education? This is the question which should be put in the foremost place before any measures can be taken by this Society in the much needed direction of photographic technology.

So far as concerns those technical subjects in which, as in photography, chemistry is largely, if not entirely, the underlying science, I am bound to confess that the impulsive character of the technical education movement to which I have referred, may, if not properly directed, run us altogether off the right track. One of the greatest functions of this Society would be to prevent such a calamity by diverting the tide of public opinion into the proper channel for its own particular subject of photography. The ideal technologist is a man who possesses a good general knowledge of the principles of those sciences underlying his industry, together with an expert special knowledge of his own subject. The first step in the training of a technologist is, therefore, to lay the broad foundation of general principles, and then to erect upon this foundation the superstructure of special knowledge. You must understand that I am attempting only to define an ideal technical training, having more especial reference to those subjects connected with, or based upon, chemical science. In the present state of affairs it cannot be denied that there are large classes to whom this method cannot be applied; there are specialists in every industry who know little or nothing of the scientific principles underlying their occupation, and in such cases the method may have to be reversed, and the instruction may have to proceed from unscientific specialism to scientific generalisation. But this method is, in my belief, only a makeshift which it may be expedient to adopt to meet existing conditions—it is not technical education in the strict sense of the word education, but the tinkering up of a system which has been bad from the beginning. It is only when we can deal with the student just starting on his career as a technologist that the true method can be applied; as things are we have many years of tinkering work before us, and it is to the rising generation of younger technologists that the future industrial welfare of the country is committed.

The danger ahead which threatens the true cause of technical education appears to me to be this:—The resources of the country are being too much frittered away in the multiplication of machinery for imparting elementary instruction, and the higher specialisation which alone will save us in the end is being crippled thereby. The elementary groundwork must be laid, and this work, as far as it is being done, cannot be done too well. But it is absurd to suppose that we shall recover our lost position in any branch of industry by scattering broadcast a knowledge of elementary science, and there leaving matters to stand. A technologist is nothing—at least in any of the subjects with which I have had connection—unless he has the means of superadding more advanced specialisation to his general grounding. So far as the chemical industries of this country are concerned, a few highly-trained specialists are worth more than an entire army of elementary certificated teachers or prize-winners. We are expending so much energy over our foundations that there is but little left for raising the superstructure. We are arming our industrial fighters with weapons which are as pop-guns compared with the heavy ordnance of our competitors. Unless those who are responsible can be made to see that the elementary training in general principles is, in a large number of subjects, quite useless unless the higher specialization is equally well catered for, we shall be no better off in these branches of technology than we were before. The elementary training bears to technology the same relationship that the tuning of the instruments does to the overture. There is a great deal of twanging and blowing going on all over the country, but, as yet, comparatively few indications of a finished performance. There is enough money in the hands of the County Councils at the present time to support technical institutes adapted to local requirements on a scale which would bear comparison with the polytechnics and technical high schools of the Continent. If each county, or group of counties, had its central technical institute, manned by competent specialists, then the elementary training might bear real fruit, and we should look forward with greater hope to the result of the campaign on which we have entered. It is not difficult to see how the fight will end if we persist in blazing away with this elementary small shot in response to the ponderous missiles of our industrial competitors.

Out of the haze of generalities which I am afraid I have been led to inflict upon you, the central idea concerning the proposed action of this Society I hope begins to loom with a more or less definite form. It is not for you to add to the general tinkling of small bells, but it remains for you to bring together a strong staff of expert ringers who can give us a good loud peal on the chimes. You will, I hope, sooner or later, set an example in technical education in your own subject—which so admirably lends itself to the purpose—which shall act indirectly on all related subjects, by showing how much of the real work of technology begins after the elementary and advanced training have been completed. The instruction imparted under the existing arrangements is good as far as it goes, but from your point of view it must be regarded as the means of supplying the raw materials out of which the technologist of the future is to be moulded. It is not your province to assist in the multiplication of elementary classes, but to set the seal of efficiency on the existing organizations.

I should have but little justification for addressing you as I have did I not feel what a splendid opportunity lies before you for raising the level of at least one important branch of technology. Still less should I be justified in responding to your invitation did I not offer some suggestions which may be of use in furthering your object. The Photographic Institute, such as we desire, would be an establishment thoroughly equipped for the best practical instruction, well provided with appliances for carrying on research in every department of the subject, and having attached to it the most competent specialists in every branch. The staff need not be numerous at first; a chemist, an optician and physicist, an expert in photo-mechanical processes, and an artist would represent the chief departments. Your committee or governing body would know the right men to select; if they cannot be found in this country you may have to go abroad for them. This course may appear ignominious, but if it has to be adopted so much the better; it will bear practical witness to the necessity of having the means of raising such men in our own country. The ideal institute may be a slow growth, but every effort should be made to establish it. The Photographic Society has already taken the initiative by proposing an affiliation with kindred Societies. This scheme should be energetically pushed forward, and every means adopted for urging the importance of the claims of photography to have a recognized technological centre. I venture to think that an impetus would be given to the movement if representatives of the Camera Club, the Photographic Convention of the United Kingdom, and of the numerous photographic Societies of the metropolis were invited to another conference, such as was held last year, but with the special object of forming a joint committee, under whose authority a further appeal might be made for public and private support. If only a moderate fund could be raised at first, operations might be commenced. Surely the numerous firms which have come into existence through the general introduction of photographic processes, and the large body of wealthy amateurs who practice the art as a pastime, might be sufficiently interested in the movement to give it their support.

It only remains now to bring these suggestions to a practical issue. We are such a very practical nation that unless something tangible is offered, the foundation of the Institute may be indefinitely delayed; as yet there is nothing of the kind in existence—there is no organized work being done that appeals directly to the patriotism and to the pockets of those to whom you may legitimately look for assistance. But elementary photography is being taught in connection with technical schools and classes all over the country. A good beginning might be made if under the auspices of the joint committee a few first-class specialists were enlisted and authorized to give short courses of demonstrations to those affiliated Societies or in those centres which desired to receive such instruction. The local centres might fairly be asked to make the necessary arrangements and to bear the small expense of local organization; the fund raised by the joint committee would be well spent at first in defraying the costs of a few special lectures. You may have some difficulty in laying your hands on the right men for this work; I need hardly remind you that the whole success of this initial movement would depend upon your sending only the most highly qualified specialists. You must have men who can teach the teachers and convince practical photographers that underlying the practice of their art are broad scientific principles which it is their interest to know something about. These preliminary peripatetic courses must be regarded in the light of missionary efforts, having for their object not the multiplication of photographic operators, but the awakening of the elementary and advanced student to the higher aspects of their subject. It is desirable to have this function of the lectures well understood at the outset; the experts who are entrusted with this work will know well enough that it is impossible to make a technologist out of a student, however enthusiastic he may be in his subject, simply by giving him a course of lectures.

If the system of itinerant instruction which I have suggested can only be fairly started, even on a small scale, one important function of the Institute will have been inaugurated. It will have a claim upon the practical educationalist as a teaching body; it will appeal more specifically to the promoters of technical education and to those public bodies which have voluntarily or by Act of Parliament identified themselves with this movement. It is certainly discouraging—I may say discreditable—when we see the magnificent scale on which the photo-technical Institutes of Berlin and Vienna have been founded and equipped, that in this country, whatever the importance of the subject, public recognition and support come only after success has been achieved by private enterprise. I am afraid you will have to reckon with this national characteristic, which, although retarding advancement in many directions, is so far good that it calls forth the most strenuous exertions to insure success at the outset of every new movement. Upon the success of your first small undertaking will depend the larger ultimate success which we all look for.

One other suggestion occurs to me which may help to strengthen your hands. I have said that instruction in photography is already being given in many technical schools; this instruction is more or less of an elementary character. It seems feasible to combine with the proposed courses of special lectures a system of inspectorship which might be carried out by the same staff. Your lecturers would be recognized experts, capable of advising such schools as to methods of teaching and of co-operating with local centres in the selection of the most highly qualified teachers. I am sure that most centres would be only too glad to avail themselves of the knowledge and experience thus placed at their service. If you begin operations on these lines at first—if you can carry on this combined system of skilled teaching and inspection successfully for a few years, your claim for permanent establishment and endowment as a Photographic Institute cannot but receive that support from public bodies to which your educational efforts will have entitled you, and which in other countries is given by the State.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—*Commencement of Hilary Term.*—The usual notices are being issued this week to undergraduates to come into residence the end of next week, full term commencing February 8. The notices state that Hilary Term will be of the usual length—eight weeks. Residence for Easter Term will begin on April 22. The dates for the examinations in Hilary Term have been fixed as follows: Preliminary in Natural Science, March 14; First Public Examination for Honours in Classics, March 17; Responsions, March 31.

It has been stated that this is the first time the date of the commencement of Term has been postponed by reason of an epidemic since the date of the Great Plague in the seventeenth century, when a whole term was abandoned.

The Senior Mathematical Scholarship has been awarded to Mr. A. E. Jolliffe, B.A., late Scholar of Balliol and Fellow of Corpus Christi; Proxime Accessit, Mr. R. C. Fowler, B.A., of New College, to whom the examiners have awarded Lady Herschel's Prize for Astronomy. Mr. H. H. Piggott, Corpus Christi, was awarded the Junior Mathematical Scholarship; and to Mr. H. A. Pritchard, of New College, the Junior Mathematical Exhibition.

CAMBRIDGE.—Mr. F. W. Dyson, B.A., of Trinity College, bracketed Second Wrangler, 1889, and Smith's Prizeman, 1891, has been elected to the second Isaac Newton Studentship, tenable from April 15, 1892, to April 15, 1895.

Mr. J. H. Flather, late Master of Cavendish College, has been appointed Assistant-Secretary for the Local Examinations.

An Exhibition of fifty guineas a year is offered by the Clothworkers' Company for proficiency in physical science. It is tenable for three years by a non-collegiate student of Oxford or Cambridge. Application is to be made to the Censor, Fitzwilliam Hall.

An influential syndicate has been appointed to obtain plans and estimates for the erection of the Sedgwick Memorial Museum of Geology on a site within the Old Botanic area, contiguous to the new Chemical Laboratory.

Dr. Forsyth, F.R.S., is appointed an additional member of the Mathematical Board for one year.

In consequence of the lamented death of Sir George E. Paget, Sir G. M. Humphry and Dr. D. MacAlister have been appointed to act for the Regius Professor of Physic, in reference to Acts for medical degrees during the vacancy in the professorship.

SOCIETIES AND ACADEMIES.

LONDON.

Mathematical Society, January 14.—Prof. Greenhill, F.R.S., President, in the chair.—The President drew the attention of the members present to the loss the Society had sustained by the recent death of Prof. Kronecker, who was elected an honorary member on January 14, 1875.—The following communications were made:—The harmonic functions for the elliptic cone, by E. W. Hobson. The harmonic functions for the circular cone were introduced by Mehler; an account of them is given in Heine's *Kugelfunctionen*. In this communication the more general functions are considered, which are required for potential problems connected with the elliptic cone. It is shown that the normal functions are of the form

$$\frac{1}{\sqrt{r}} \begin{matrix}\sin\\ \cos\end{matrix} (p \log r) \,.\, A(\mu)\, B(\nu),$$

where r is the radius-vector, and μ, ν are elliptic co-ordinates, the functions A, B satisfying differential equations which differ from Lamé's equation only in having $-\frac{1}{2} + p\sqrt{-1}$ instead of n; thus the functions A and B are Lamé's functions of complex degree. The forms of these functions as required for the potential problem are considered, and some examples of their application are given.—Some theorems relating to a system of coaxal circles, by R. Lachlan. This paper is based on a suggestion contained in a short note by Dr. A. S. Hart in the *Quarterly Journal* (vol. ii. p. 143), who indicated a simple and elementary method of obtaining Poncelet's theorem. In the present paper this method is discussed in detail. Poncelet's theorem may be thus stated: *If $A_1, A_2, A_3, A_4, \ldots A_n$, be n points taken in order on the circumference of a circle S, so that any $(n-1)$ particular connectors of the polystigm $A_1A_2 \ldots A_n$ touch fixed circles coaxal with S, then the remaining connectors of the figure will envelop circles which belong to the same coaxal system.* If now $S_{p,q}$ denote the circle which is touched by the chord A_pA_q, it is proved that if $(n-1)$ connectors of the polystigm touch any $(n-1)$ of the circles $S_{1,2}, S_{1,3}, \ldots, \ldots S_{n-1,n}$, the remaining connectors of the polystigm will envelop the remaining circles. A few special cases are then discussed, among which the most interesting is the case of $2n$ points $A_1, A_2, \ldots A_{2n}$, taken in order on a circle S, so that the chords $A_1A_2, A_2A_3, \ldots A_{2n}A_1$, touch another circle S′: it is then proved that the n chords $A_1A_{n+1}, A_2A_{n+2}, \ldots A_nA_{2n}$, must intersect in a limiting point of the circles S and S′, and that the remaining $2n(n-2)$ connectors may be divided into $(n-2)$ sets of $2n$, each set being tangents to a circle coaxal with S and S′. Further, it is proved that the $2n(n-1)$ connectors which do not intersect in the limiting point may be arranged in $n(n-1)$ pairs, each pair touching two circles of the system.—Note on the formula for the number of classes of binary quadratic forms of a given determinant, by Prof. G. B. Mathews.—Researches in the calculus of variations (third paper), by E. P. Culverwell.—Mr. E. B. Elliott, F.R.S., made a short oral communication on a generalization of De Morgan's method of duality in partial differential equations. He exhibited schemes of linear substitution for one set of variables in terms of another set of first derivatives, which have the self-dual property, discussing the cases of two and of three independent variables.—Major MacMahon, F.R.S., mentioned the "stamp-folding" problem, at which Prof. Schoute, of Groningen, has been working. For a strip of stamps (one stamp width), the following results, when the strip is folded so that the face (or back) of one stamp only is exposed, were given: (1) = 1, (2) = 2, (3) = 6, (4) = 16, (5) = 50, (6) = 144, (7) = 462, (8) = 1398 (?), (9) = 4527. For squares, the results given were (2) = 8, (3) = 296, (4) = 13007 (?). (9) is found to give more than $2\frac{1}{2}$ billions. The law of formation of the numbers is sought.—Messrs. Basset, Love, Kempe, Hobson, Prince C. de Polignac, and the President spoke upon the papers.

Linnean Society, January 21.—Prof. Stewart, President, in the chair.—On a motion by the President, it was unanimously resolved that an expression of respectful sympathy should be conveyed to Her Majesty the Queen, and to H.R.H. the Prince of Wales, on the loss sustained by the death of H.R.H. the late Duke of Clarence and Avondale.—Mr. M. F. Woodward exhibited microscopic sections illustrating the development of the teeth in the Marsupialia. He drew attention to Prof. Kükenthal's recent discovery of supposed rudimentary successors in all the teeth, thus showing that the adult set of teeth must be regarded as belonging to the first or milk series, and not, as generally supposed, to the second or successional dentition. These statements he was able to confirm for the incisors and second upper molar of *Didelphys*. In the Phalanger (*Trichosaurus*) he found no trace of these structures in connection with the molar teeth, but they were present with the upper incisors. In no case did these rudimentary successional teeth pass beyond the condition of simple down-growths from the enamel organs of the functional teeth.—Mr. J. W. Willis Bund exhibited a supposed hybrid between the common and red-legged partridges, but in the opinion of ornithologists present it was regarded as merely a variety of the former species.—Mr. J. C. Mansel Pleydell exhibited a pair of malformed horns of the roebuck found at Whatcombe, Blandford, Dorset, their peculiar growth resulting from exostosis consequent upon injuries sustained while in the sensitive condition.—Mr. D. Morris communicated some further notes upon the tick-pest of Jamaica, upon which an animated discussion took place.—A paper was then read by Mr. F. E. Weiss "on the development of the caoutchouc-containing cells of *Eucommia ulmoides*, Oliver." He found that the bark and leaves of this tree, used medicinally by the Chinese, and called by them "Tu-chung," contain numerous elastic threads of silky appearance, which proved to be of the nature of caoutchouc. They are contained in long, unbranching cells, somewhat like latex cells, which are found in the cortex and in the secondary phloem, and accompany in large numbers the ramifying bundles of the leaf and the pericarp. Unlike the ordinary latex cells, they are not derived from specialised cells of the embryo, but originate in all new growths, and can be seen forming in the cortex, the pith, and the parenchyma surrounding the bundle of the petiole. They originate in twos, by longitudinal division of a very granular cell, both daughter cells growing out at their two extremities into a long tube, which makes its way along the intercellular spaces by sliding growth. They never contain more than one nucleus, and the large granules of caoutchouc, which soon make their appearance, finally coalesce into a single solid mass, which has, when the tissues are broken, the appearance of a silky thread. Mr. Weiss regards these cells as a primitive form of latex cells, similar to those from which the more elaborate ones of the ordinary *Euphorbiaceæ* may have been derived.—The meeting was brought to a close with a paper by Dr. Jean Müller on the Lichens of Manipur.

Royal Meteorological Society, January 27.—Annual General Meeting.—Dr. W. Marcet, F.R.S., Vice-President, in the chair.—The Report of the Council for the past year showed the Society to be in a very satisfactory position. In May the library and offices were removed to more commodious premises at 22 Great George Street. After defraying the cost of fitting up the new offices, and the increased rental, there still remained a balance in hand of £224. Thirty-four new Fellows were elected during the year, the total number on the roll of the Society now being 552. Owing to the absence of the President, Mr. Baldwin Latham, through an attack of influenza, his address on "Evaporation and Condensation" was read by the Secretary. The question of evaporation is of as great importance as the study of the precipitation of water on the face of the earth, as the available water supplies of the country entirely depend upon the differences between these two sets of observations. The earth receives moisture by means of rain, dew, hoar-frost, and by direct condensation. It loses its moisture very rapidly by evaporation. Although evaporation mainly depends upon the difference between the tensional force of vapour due to the temperature of the evaporating surface, and the tensional force of the vapour already in the atmosphere, yet it is largely influenced by the movement of the air and by its dryness, or the difference between the dew point and the actual air temperature. Evaporation goes on at night so long as the water surface is warmer than the dew point. With sea-water the evaporation is about $4\frac{1}{2}$ per cent. less than with rain water, while with water saturated with common salt the evaporation is 15 per cent. less than with rain water. In his experiments Mr. Latham used an evaporating gauge made of copper, 1 foot in diameter, and containing 1 foot in depth of water, which was floated by means of a hollow copper ring placed 6 inches distant from the body of the evaporator, and attached to it by four radial arms. This form of evaporator was found extremely convenient in carrying on all evaporation experiments; it was floated in a tank 4 feet in diameter, containing 30 inches depth of water. During the period of thirteen years, from January 1879 to December 1891, this evaporator has never once been out of order, or been interfered with in the slightest degree by frost. Experiments were made with some 5-inch evaporators as to the effect of colour on the amount of evaporation, one being painted white, another black, and the results given by these gauges were compared with a copper gauge exposed under similar conditions. This comparison was the means of showing that the greatest errors in evaporating gauges arise from the capillarity of the water rising on the sides of the gauge, and thus inordinately increasing the amount of evaporation. Consequently a small gauge having a larger amount, in proportion, of side area than a larger gauge, gives a very much greater amount of evaporation. The results from the floating evaporator, 1 foot in diameter, show that the average amount of water evaporated annually during 1879–91 was 19·948 inches. It was found, however, that, as a rule, during the period from October to March, there were certain occasions when condensation was measured. The amount of these condensations in thirteen years averaged ·308 inch per annum. The 5-inch evaporating gauge, freely exposed to atmospheric influences, gave during the same period (1879–91), an average annual depth of evaporation equal to 38·185 inches. The average annual evaporation, during the three years 1879–81, from the 5-inch copper gauge standing in water was 27·90 inches, from one painted black 22·97 inches, and from another painted white 21·74 inches, whilst a gauge of the same dimensions, freely exposed in the atmosphere, gave, in the same period, 36·96 inches, and the 1 foot floating evaporator, 19·40 inches. The 5-inch copper gauge gave a larger amount of evaporation than the gauge painted black.—Mr. Latham next described some percolation experiments which were carried out by Mr. C. Greaves at Old Ford, by Messrs. Dickinson and Evans at Hemel Hempstead, and by Sir J. B. Lawes and Dr. Gilbert at Rothamsted. He then detailed the results of his own experiments, and also the gaugings of the underground waters in the drainage areas of the rivers Wandle and Graveney. He further stated that in the course of his observations on the flow of underground water, he had observed that at certain particular seasons of the year it was possible to indicate the direction and volume of the flow of underground streams, even when they were at a considerable depth, owing to the formation of peculiar lines of fog.—Dr. C. Theodore Williams was elected President for the ensuing year.

PARIS.

Academy of Sciences, January 26.—M. Duchartre in the chair.—On the properties of the loxodromics of a cone of revolution, and their application to the conical spring, by M. H. Resal.—*Résumé* of solar observations made at the Royal Observatory of the Roman College during the last quarter of 1891, by Prof. Tacchini. Spots and faculæ show a slight diminution when their frequency is compared with that of the preceding quarter. On no day, however, has the sun been observed free from spots.—Experimental study of the decimal equation in transit observations, made at Lyon Observatory, by MM. André and Gonnessiat.—On a real algebraical curve with constant torsion, by M. E. Fabry.—On the characteristic equation of water-vapour, by M. Ch. Antoine. The author shows that the weight, ϖ, of a cubic metre of water-vapour at a temperature t, and under a pressure H, is given by the relation

$$\varpi = \frac{19{\cdot}9H}{278 - 0{\cdot}365\theta + t},$$

in which θ represents the temperature of the vapour at saturation under the pressure H.—Remarks on the subject of the experiments made by M. Gouy on the difference of potential produced by contact, by M. H. Pellat.—On Hertz oscillations, by M. A. Perot. In a recent work (*Wiedemann's Ann.*, xliv. pp. 74 and 92) Bjerknes shows that the oscillations of electromotive force produced in a conducting wire by Hertz's method ought to be represented by the equation—

$$Y = Ae^{-a(t-\theta)} \sin \pi \left(\frac{t}{\tau} - \phi\right).$$

M. Perot finds that the formula proposed is supported by experiments.—On aplanatism, by M. A. Broca.—The estimation of molybdenum, by M. E. Péchard. The compound containing the molybdenum is heated in a current of HCl, when $MoO_3.2HCl$ volatilizes, is collected, dissolved in water, with the aid of nitric acid if any of the blue reduction compound is formed, and the solution evaporated to dryness; the molybdic acid is then weighed.—On the stereochemical constitution of diacetyltartaric acid, by M. Albert Colson.—On some soluble colouring-matters produced by bacteria in medicinal distilled waters, by M. L. Viron.—On the existence of nitrification phenomena in media rich in acid organic substances, by M. E. Chuard.—Ammonia in rain-water and in the atmosphere, by M. A. Muntz.—In a former paper the author stated that the rain-water of tropical regions was richer in ammonia than that of temperate climates. This conclusion was combated by M. Lévy, who showed that the proportion of ammonia in rain caught at Montsouris was greater than that recorded by M. Muntz. The latter gentleman now points out that the observations made at Montsouris, or near any populous district, do not furnish proper criteria for the judgment of his first statement.—Earthworms and the bacilli of tuberculosis, by MM. Lortet and Despeignes.—On the inoculation of *dourine*, by M. Ed. Nocard.—Researches on the nervous system of Crustacea, by MM. F. Jolyet and H. Viallanes.—On the pelagic fauna of Dyrefjord (Iceland), by M. G. Pouchet.—On an elliptical halo observed around the moon on January 14, 1892; extract from a letter addressed to M. Cornu by M. Hamy.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

BOOKS.—L'Évolution Sexuelle dans l'Espèce Humaine: Dr. H. Sicard (Paris, J. B. Baillière).—Les Problèmes de la Géologie et de la Paléontologie: T. H. Huxley (Paris, J. B. Baillière).—Report on the Scientific Results of the Voyage of H.M.S. *Challenger*; Deep-Sea Deposits (Eyre and Spottiswoode).—Treatise on Chemistry, vol. iii. Part 6: Sir H. E. Roscoe and C. Schorlemmer (Macmillan).

PAMPHLETS.—Guide to the Examinations in Chemistry and Answers to Questions: W. J. Harrison (Blackie).—Guide to the Examinations in Geology and Answers to Questions: W. J. Harrison (Blackie).

SERIALS.—The London and Middlesex Note-book, vol. i. No. 4 (Stock).—Bulletin de l'Académie Royale des Sciences de Belgique, No. 12, tome 22 (Bruxelles).—Quarterly Journal of the Geological Society, vol. xlviii. Part 1, No. 189 (Longmans).—Rendiconto dell' Academia dell' Scienze Fisiche e Matematiche (Sezione della Società Reale di Napoli), January–December 1891 (Napoli).

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