THURSDAY, OCTOBER 12, 1899.

VERWORN'S "GENERAL PHYSIOLOGY."

General Physiology. An Outline of the Science of Life. By Prof. Max Verworn. Translated from the second German edition by Dr. Frederic S. Lee. Pp. xvi + 615. (London: Macmillan and Co., Ltd., 1899.)

WE cordially welcome the appearance of an English translation of this well-known book. The first (German) edition appeared in 1894, and was noticed at some length in this journal (vol. li. p. 529). The in erest which it excited is testified to by the practical fact that a second edition in German was called for in 1897, while translations into English, Italian and Russian have also appeared.

The second edition differs from the first only in detail. The general plan remains the same, though, as the author remarks in the preface, the more important results of the very large number of researches in the physiology of the cell which have appeared during the last few years have been added.

The scope of the book is "an attempt to treat general physiology as general cell-physiology," and thus to outline a field in which the various branches of special physiology might unite. The author is at some pains to define the cell as the unit of organised living matter—the smallest part which can maintain an independent existence; it is the "elementary organism." Having described this unit, and discussed its structure and chemical and physical constitution and the way in which the substance of which it is composed differs from non-living substance, the author proceeds to a consideration of the phenomena which are manifested by cells in general. He is thus led to a discussion, firstly, of the internal phenomena of life in their most general aspect—of change of substance or metabolism, of change of form, and of change of energy; and, secondly, of the external relations of living matter, of food, of effects of temperature, &c., of stimuli, of the origin of life on the earth, and of the process of dying. Lastly, he returns to a consideration of the nature of the material of the cell, and seeks there an explanation of these internal and external phenomena. These inquiries are sufficiently wide; but the author, not content with them, includes an interesting history of physiological research, in which he rightly endeavours to justify his own standpoint by an appeal to the development of the science; and a discussion, in true Ercles vein, of the relation of physiological research to metaphysics in which, among other things, the investigator is invited to "get rid of the error of the existence of a physical world outside the mind"!

Those who have made acquaintance with Prof. Verworn's views in other and earlier publications, as, for instance, in papers published in the *Monist* (*cf.* NATURE, li. p. 58), will not be surprised to learn that the tone of the book is somewhat aggressive. He has set himself the task of recalling physiologists from the barren field of "one-sided specialisation," whatever that may mean, to a renewed consideration of the ultimate problems of life. He is impatient with the "impotence of the physiology of to-day in the presence of the simplest vital processes." The outworks are down, why do the workers stay prying into the ruins when they should press on to attack the central citadel, the cell, wherein the simple secrets of these simplest of processes are hidden?

No fault can be found with the purpose which is outlined here, but unfortunately the reader's sympathies are apt to be lessened by a lack of restraint and reticence in the advocacy. There is an unpleasant tone of special pleading running through the pages, which inevitably raises the suspicion that the author's outlook is perhaps not so broad as he would have us believe.

A good wine needs no bush, and the virtues of an endeavour to bring together all that is known of the general properties of living matter suffer when heralded by an impeachment of the past achievements of physiology which is phrased so as to convey the idea that the nature of the processes which constitute life has not been touched on. In point of fact, the knowledge gained, amongst other things, of the internal respiration of muscle, of the automatic phasic activity of the cardiac and other tissues (due, by the way, mainly to the work of Gaskell, and not to that of Engelmann, as the author states), and of the special processes of storage and discharge in glandular organs, has led to a first approximate conception of the character of the changes, both in matter and energy, which waits for further development, not upon the labour of biologists, but upon that of workers in the domain of molecular physics.

It is possible that the central idea of the book—the assertion of the identity of general physiology with cell physiology—is founded upon a misconception, and we are inclined to doubt whether any special virtue is likely in the future to flow from the study of the cell. If the cells in question form part of tissues or organs, then the methods are the methods which have been employed in the past. The study of the cardiac muscle cell is the study of the heart, of the secreting cell that of the gland which holds it, and so on. Practically, as one learns by perusing Prof. Verworn's pages, what is really new in his method is confined to the exaltation of the importance of the study of the cell when it is an independent individual, such as one finds in the members of the Protozoa. In this field he has himself laboured with no small measure of success. The phenomena exhibited by free-living cells are unquestionably of surpassing interest, but, unfortunately, the study of the relatively diffuse activities which they manifest must be of secondary importance, seeing that the facts which are gleaned can only be interpreted by the aid of that insight into the finer anatomy of function which springs from a study of the highly specialised organs of the higher types where the activities of living matter are, as it were, analysed for us.

This is not the only drawback. There is another, and perhaps more serious one, which the author nowhere stops to discuss. It lies in the difficulty which exists when minute forms are used for experiment in deciding how far a given result is a true physiological reaction to a stimulus, and how far it is a purely mechanical effect. For instance, under the heading of galvanotaxis, and in the section dealing with the general effect of electrical stimuli, a description is given of the way in which animalculæ become grouped round one of the poles, while individuals suffer actual alteration in shape under the influence of a constant current. But, as Faraday was the first to show, small particles of any kind are driven to one or other pole when suspended in fluid through which a current is passed, and a rod of jelly suffers compression at one end and expansion at the other under the mechanical stresses produced by the passage of a current.

The general tone of the book is inspired by an impatience with the laggard pace of knowledge—the "foster-child of silence and slow time," if one may wrest a phrase of Keats from its setting—which prompts the taunt that the physiology of to-day is impotent in face of the simplest vital processes. Unfortunately, it is not controlled by a true feeling for the relation of the knowledge of living matter to the progress of the general knowledge of matter. The tools with which the attempt to fashion a dynamical explanation of the phenomena of life must be made are themselves still in the making. It is barely ten years since what was practically the new science of molecular physics was founded at the meeting-place of chemistry and physics by the labours of Guldberg and Waage, Arrhenius, van 't Hoff, Gibbs, Ostwald and others. On the growth of this science the biologist must wait, and, though the advances which it has made are prodigious, they are concerned wholly with the crystalloid type of matter—they have not yet embraced the colloid type which is the physical basis of life.

The completeness of our ignorance of the latter type is manifested with almost dramatic force when one finds all that is known of colloidal matter lying in the compass of a page or two of a text-book such as that of Ostwald or of Nernst, whereas the account of the crystalloid type stretches to many hundreds! Reproaches and hasty generalisations are equally out of place in the face of this colossal ignorance of the elements of the problem; and one feels the practical wisdom of physiological workers in devoting themselves to what may be called the anatomy of function—that is, the interpretation of organ and tissue activities in terms of the fundamental properties of living matter, rather than in kicking against the barriers which the general state of knowledge opposes to the translation of these fundamental properties into terms of matter and motion.

The same lack of a sense of the historical position of biology caused Bunge to drift into vitalism, which at any rate has the merit of recognising the difficulties which stand in the way of a dynamical explanation of metabolism, irritability, and the recurrent cyclic character of the phenomena of life.

Prof. Verworn, however, is impelled to the opposite extreme—a materialism, often rash, which leads him to a disastrous quest for "simple explanations," in which his knowledge too frequently becomes wire-drawn to the breaking point. The "mechanical explanation" which he offers of the "so-called" selection of food will serve as an instance. A cell bathed by a nutrient fluid such as, *e.g.*, an epithelial cell absorbing material from the lumen of the intestine, is likened to a crystal growing in its mother liquor. Like its analogue, it withdraws only special substances from the common nutrient fluid, "as is evident from the fact that gland, muscle and cartilage cells produce wholly different and characteristic substances." Hence the conclusion that the selection of food is only a special manifestation of chemical affinity, and that "it is an absolutely necessary consequence of the fact that the living substance of every cell possesses its own specific composition and its own characteristic metabolism." So in place of the healthy recognition of a difficulty we are offered a cumbrous platitude and a leap in the dark!

The simple explanation which is offered of the fact "which must otherwise appear very wonderful" (*sic*), that among the innumerable swarm of spermatozoa cast into the sea, every species finds its proper ovum, also deserves mention. It "is explained very simply by the further fact that every species of spermatozoon is chemiotactic to the specific substances that characterise the ovum of the corresponding species." The robe of modesty is more fitting than the gown of counsel for explanations like these!

In other cases the haste for simple explanations leads to a mode of treatment of problems of acknowledged difficulty which intensifies the obscurity. Thus some space is devoted to urging that there is no distinction between the motor impulse or the electric current in their action upon, for instance, muscle fibres and that relation between motor nerve cell and muscle fibres which, when it is broken by severance of the connecting nerve, causes degeneration of the latter. This view is distinctly opposed to the results of recent work upon muscular tone, and upon the effects of section of the roots of spinal nerves which tend to emphasise the distinction between the calling out of special activity by special nervous impulses and the fact that many highly specialised cells are dependent for their continued well-being, even for their capacity to respond to stimuli, upon their functional continuity with other and totally dissimilar cells. We are ignorant of the nature of the latter relation, though it may well be one of simple dynamical equilibrium rather than one dependent upon the passage of nervous impulses. But Prof. Verworn starts in a panic from this unsolved problem. He sees in it a piece of the old mysticism of the vitalists, and, in order to compass a simple explanation, trophic relations are grouped with the action of electric and chemical stimuli and of food into one class which lacks both order and form.

In spite of these defects in general tone, the pages of the book furnish abundant justification for the success which it has already attained. The point of view which the author has adopted has led him to bring together a body of facts, many of them little known, in a manner which cannot fail to be stimulating and suggestive to both physiologists and morphologists. Many gems of thought, too, are to be found, especially in the later chapters. The sections on the directive effects of unilateral stimulation, chemiotaxis, barotaxis, &c., are singularly interesting, and so too is the conclusion which is drawn from the facts, namely, a general application of the principle of the specific energy of sense-substances.

"All living substance possesses specific energy in Müller's sense: with certain limits wholly different stimuli call forth in the same form of living substance the same phenomena, while, conversely, the same stimulus in different forms produces an effect wholly different and characteristic for every form."

The treatment of the dynamics of movement as a polar change in the resultant of the anabolic and katabolic processes in the cell, or "biotonus," as the author calls their algebraical sum, is equally illuminating, as are also parts of the mechanics of cell metabolism.

The pages dealing with actual facts, which after all make up by far the greater part of the book, possess an enticing feeling of freshness and novelty which is born of the fact that the author's special studies have lain out of the beaten track. For this and for the intrinsic interest of the facts themselves we feel grateful to him, and we heartily wish success to the English edition. The translation bears abundant evidence of the care which Prof. Lee must have lavished upon it. It is a monument of clearness throughout. W. B. HARDY.

OUR BOOK SHELF.

Living Pictures. By H. V. Hopwood. Pp. xii+275. (London: *The Optician and Photographic Trades Review*, 1899.)

THIS is a very interesting review of the gradual evolution of the various instruments which have been invented for the portrayal of objects in motion, from the earliest times to the present day. The work may be divided into two parts, of which the first, including Chapters i.–iii. (pp. 1–109) deals with the more distinctly historical aspect of the subject, while the remaining chapters (iv.–vii.) are devoted to a very minute description of all the important machines in present use.

Chapters i. and ii., on the "Persistence of Vision," &c., contain a lucid account of the principles governing the phenomenon of a succession of different views of the same object giving the impression of the object being in motion. In this part all the instruments, whether as toys or scientific apparatus, are described in the order of their invention, beginning with the simple colour tops and thaumatrope put forward as early as 1826. The host of improvements from this time up to about 1878 were attempts to remedy the difficulty of so small a percentage of light passing the two slits at first used for the intermittent view. This section concludes with descriptions of the modern mutoscope and viviscope.

Chapter iii. (pp. 43–109) commences with the invention of "chronophotography," and gives a complete description of the more important of the inventions brought out from 1865–1895. The mechanical details in connection with the alternate exposure and movement of the sensitive surface receive special attention, the difficulty of following these being greatly lessened by the numerous illustrations accompanying the text.

Chapter iv. is devoted to present-day apparatus, and all the machines which have appeared before the public receive ample notice, in most cases accompanied by a woodcut showing the internal arrangements.

Chapters v. and vi. deal with the processes adopted in making the films, their exposure, development, printing, &c., and also give ample practical instructions for exhibiting the pictures in the lantern.

At the end of the volume two most useful appendices are given. The first is a "Chronological Digest of British Patents," giving a short *résumé* of all specifications taken out in connection with living pictures from the time of Fox Talbot (1851) to the end of December 1898.

The second appendix is an annotated bibliography of all publications (British and foreign) from 1825 to the present time, which bear on the subject.

The numerous illustrations (242), which are well chosen and very clearly printed, render the following of the necessarily somewhat technical matter exceedingly interesting even to the non-expert. The book will be welcomed by many to whom the methods of cinematography are a mystery, as by its aid any one even strange to the subject may easily understand the working of any of the machines in past or present use.

Tables and Data. By W. W. F. Pullen. (Manchester: Scientific Publishing Company, 1899.)

IN these eighty-seven pages Mr. Pullen brings together tables and data which will be found very serviceable in engineering laboratory work and in the solution of class problems and exercises in mechanical engineering. Points perhaps of special mention are that the general steam table is carried up to 300 lbs. per square inch; the diagram for determining the dryness of steam with the throttling calorimeter is plotted on a large scale, and the melting points of various substances has been revised by Sir William Roberts-Austen. For facility of reference the British and metric measures are placed side by side. The remaining portion of the book is devoted to mathematical notes on mensuration, geometry, trigonometry, &c., with a synopsis of mathematical data. At the end are added a few extra pages, some of which are blank, while on others are printed diagrams of millimetre paper, for the insertion of any additional curves the student may wish to insert. Not only engineering students, but others should find the contents of this book a useful laboratory *vade-mecum*.

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.*]

Halo Round a Shadow.

IN your issue of this week Prof. S. Newcomb draws attention to the halo which an observer often sees round the shadow of his own head when the ground on which the shadow falls is covered with vegetation or any obstructions which can themselves cast shadows.

In a letter to NATURE in 1878 or 1879 (I have not the reference by me) I mentioned this phenomenon, giving the same explanation as your recent correspondent, and adding that the angular width of the halo was settled by the ratio of the mean diameter of the obstructions to their distance from their own shadows.

The halo (or spot of light, if the observer is too far off for his own shadow to show) can be seen very well when the ground is covered with heather or bracken whose twigs and leaves are small compared to their height above the ground.

3 Victoria Street, S.W., October 6. A. MALLOCK.

The Skull of Hatteria.

IT may be worth while to draw the attention of naturalists to an omission in the figures of the skull of that archaic reptile, the Tuatara, that occur in two recent text-books of somewhat wide circulation, viz. Parker and Haswell's "Text-Book of Zoology" and Reynolds's "The Vertebrate Skeleton." These figures are either copied or redrawn from Zittel's figure published in his well-known work on Palæontology. This figure appears to have been drawn from an imperfect specimen, as the "transverse" (or transpalatine) bone is omitted in the ventral view; it is *apparently* represented in the dorsal view, however, though there is no index line in the original. The bone, though of considerable size, very readily drops out of a thoroughly macerated skull, from which the figure was no doubt drawn. There is really no excuse for our English authors borrowing the figure from a German book in this instance, for Dr. Günther's picture of the skull published in the *Phil. Trans.*, vol. clxvii., is perfectly accurate, except in regard to nomenclature of some of the bones, while Zittel's is most indistinct.

Dunedin, N.Z., August 30. W. BLAXLAND BENHAM.

THE BEST EDUCATION FOR AN ENGINEER.[1]

AN admirable address, well thought out, well delivered, and received with bursts of applause, which were so enthusiastic that they sounded like volleys of musketry. We are still in the early days of the history of technical education, and such deliberate expression of opinion by those who are connected with the engineering industry are much needed on the subject of the early training of the engineer; and when the speaker is Sir Andrew Noble, in whose works 30,000 gain their living, and when, in addition, he says what he really thinks, and does not merely confine himself to complimentary remarks about the College in which he is speaking, his address cannot fail to command close attention.

On two important occasions captains of industry, when referring to the early education of those who afterwards go to the City and Guilds Technical Colleges, have enlarged on the value of a classical training—Mr. Alexander Siemens in 1892, and now Sir Andrew Noble. Now, why is this?

A considerable proportion of those who have made their mark undoubtedly received a classical education, but one asks, Was it the classical education that made them famous, or was it their great natural ability, and consequent success, that made the reputation of classical education? Or is there some other and deeper reason for this advocacy of the study of the language and literature of the peoples who, near the beginning of our era, occupied a small portion of the earth as we now know it? Not certainly the argument so frequently urged—urged even by Sir Andrew Noble in this address—that a student of science should study classics to better understand the meaning of scientific terms. This will teach him that "geometry" means "land surveying," and leave him disappointed that six books of Euclid do not enable him to measure an irregularly shaped field; his Greek will tell him that a "logarithm" is a "proportion number," but a book of them will still be Greek to him. That it is a mĭcrophonē that is used in sending a message to a tēlĕphonē will provoke a laugh from the man in the street, and if to a knowledge of classical grammar the student of science adds that of his own language, he will realise that one reason why it is so difficult to obtain a "reliable" measuring instrument is because such a thing is impossible, for the verb "to rely" must be followed by the preposition "on."

No! such a utilitarian argument in favour of classical study is rather a confession of weakness. Nor—as is so often alleged—is a classical study of importance because it facilitates the learning of modern languages. For many are the Dutch, the Poles and the Russians who talk with exasperating volubility in one's own language, wherever one may have been born, but who know less Greek and Latin than an Eton boy whose linguistic powers are as insular as himself.

A study of the classics and a public school education are frequently regarded as synonymous, and so the advantages of the one are confounded with the advantages of the other. At the present time, when so much attention is devoted in secondary and technical schools to *matter* rather than to *manner*, when the aim apparently is to turn out scientific encyclopædias rather than fairly well-informed people with cultivated manners, the following opinion expressed by Sir Andrew Noble should be taken to heart by every engineering student:

"Speaking as an employer of labour, I should say that we find a pleasant speech and manner, tact in dealing with others, and some power of organisation of the utmost value; and it is precisely those qualities which a boy acquires, or ought to acquire, in his *later* years at a public school. Without such qualities even the highest scientific attainments will never make a captain of industry, and in selecting candidates for appointments the man of business distinctly prefers a youth who has had the benefit of some years at a good school."

But this polish, we urge, might equally well be acquired were the study of Japanese or the production and use of the electric current, or the action of mechanical forces, substituted by a *thoughtful* teacher in a public school for that of Greek and Latin. For that cultivation, which we all value so highly, is not produced by the association of a lad with *dead* writers of exceptional ability, but with *living* lads of his own standing, coming, like himself, from homes where refinement and right feeling pervade, and all, like himself, bent on preserving a tradition which, though sometimes foolish, sometimes rough or even brutal, still tends on the whole towards civilisation. It is not so much the *study* as the *life* of a public school boy that is so valuable in forming his character.

But if that be the case, is Sir Andrew justified in deducing the following conclusion?

"My own impression with regard to early education is that, as a sharpener of the young intellect, and as a mental discipline, it would be difficult to improve upon the curriculum which is now in force at our public schools, and which, in the main, has been in force for so many centuries."

The curriculum of a public school is, we think, not exempt from the rule that what man has devised can always be improved. A classical education, the staple of the public school curriculum, has undoubtedly the great advantage that some of the greatest thinkers in the past spent the early part of their lives in receiving it, and the latter portion in giving it to others. It is, therefore, the particular form of training that has been carefully thought out, and its development is the result of long years of trial and error. Further, it possesses another advantage, the value of which does not seem to have received the recognition it deserves, and this is that when the merest dullard is puzzling out some passage with the aid of dictionary and grammar, he is really engaged in a small way on precisely the same kind of work that enchants the greatest scientific investigator, viz. finding out for himself something that he wants to know.

Now this by no means characterises the work of all the students in a well-fitted modern laboratory. Not a few, following the instructions, spend hours taking readings of instruments and tabulating the results, but fail to find out what is the meaning of these results, or even what is the object of the experiment itself. They have, in fact, been laboriously grinding at the handle of the barrel organ, but have been mentally deaf to the tune that it played.

Heartily then do we join with Sir Andrew Noble in deprecating training of this kind—whatever it may be called—and agree with him that even when all technical study is postponed until after school and college life:—

"Those men who, with fair abilities, have received a really good education, have been taught to use their minds, and who, by contact with other students, have acquired habits of application, amply make up for their late start by the power of mind and grip that they bring to their work."

But can these qualities, we ask, only be acquired by confining a boy's attention to the study of words and ideas, and by excluding all study of nature and things? Sir Andrew himself states:—

"In nine cases out of ten, I should say, any knowledge acquired by a boy before he is sixteen can have but a slight intrinsic value. Up to that age, it is not *what* he learns that we have to look at, but *how* he learns; it is the habit of discipline, of mental application, of power in attacking a subject, that are so valuable; not, generally, any definite piece of knowledge he may have gained."

Now surely "the habit of discipline, of mental application, of power in attacking a subject" is exactly what

[1] Inaugural Address of the Session 1899–1900 of the City and Guilds Central Technical College, given at the College, Exhibition Road, by Sir Andrew Noble, K.C.B., F.R.S., on Tuesday, October 3.

can be learnt from a *proper* study of science, and, so far from any knowledge acquired by a boy before he is sixteen having but a slight intrinsic value, is it not a fact that all knowledge requiring mechanical dexterity, such as reading, writing, arithmetic, riding, swimming, talking foreign languages, playing a musical instrument, &c., can be far better acquired before the age of sixteen than later, and are not all these examples of knowledge possessing intrinsic value?

We are, however, quite at one with Sir Andrew in thinking that

"the age at which a boy should seriously begin any special studies, with a view to fit him technically for the profession he may have decided to follow, should not be earlier than seventeen or eighteen."

But should not a sharp distinction be drawn between learning technology and acquiring the elementary principles of science? His warning that the zest for your life's work may be weakened by embarking on it too early certainly furnishes a potent, probably the most important, reason why lads who intend to become engineers should wait until they are eighteen, or at any rate seventeen, years old before they commence their professional education; for then, as is said in the address, they will be

"fresh and keen when others, who have been hammering away at semi-technical work from early boyhood, have become stale and are less vigorous."

For the same reason also, time devoted by a lad to learning off strings of scientific facts would be misspent, but not so, we think, would time given by even a child to the acquisition of scientific habits of thought. We do not defer teaching a lad the principles of morality until he is seventeen or eighteen for fear he should become tired of living a moral life, why then should the risk that a lad might weary of leading an intellectual one frighten us into excluding the principles of science from a good education?

In the address, "science, mechanical drawing, and such like" are classed together as things that may with advantage be omitted from the training of a lad before entering Elswick, provided he has had a good education. But can an education of the present day be termed "good" which lacks a training in those mental qualities which are classed under the head of scientific?

Great stress was laid by Sir Andrew Noble on the value of the knowledge which a person has gained for himself. He cited the results which "dauntless energy, untiring industry and patient search after truth" had achieved for Lord Armstrong, Watt, Stephenson and Faraday, but only as a proof "that a special technical education is not an absolute necessity." Do not the lives of these men, however, teach us much more than this, viz. that the particular system of education, classical, mathematical, scientific, artistic or technical—in fact, any system of education ever invented—is less than nothing in enabling a man to rise to the top in comparison with the determination to succeed and the brains to do it?

The reason why certain branches of industry have almost abandoned this country, and why new branches that have been developed abroad have hardly taken root with us, is a topic deeply interesting to the manufacturer, but generally rather distasteful to the student, since he would prefer to be told that everything was done better, more cheaply and more expeditiously in his own country than in any other. Sir Andrew Noble, however, made even the part of his address which dealt with this subject appeal strongly to his audience, and for a remedy he thought that it was

"to theoretic and technical knowledge that we must chiefly look. Consider, as an illustration, electricity in the service of man. Think of its innumerable applications, and of the number of hands dependent upon its industries. But for one man capable of designing or improving these powerful machines or delicate instruments, there are a thousand ready and able to carry out their designs. But it is the former who are the salt of the earth, and those who have the management of large concerns know well how to value them."

His patriotic statement (for it is true patriotism to help your own countrymen to learn the truth even if it be distasteful) that the success of our German competitors was *not* due "to their putting on the market inferior goods specially got up to imitate those of a superior class," but "to the far greater opportunities of technical study which are afforded in Germany," was as bold as we believe it to be true. For we were recently informed by an English manufacturer that certain things manufactured in England are now being stamped "Made in Germany," in order to obtain a readier sale for them in our own country.

But in addition to greater facilities being needed in Great Britain for the study of the applications of science to industry, greater belief in the value of such study is wanted, not only on the part of the English manufacturer, but also on the part of the English student. "You younger men," said Sir Andrew, "must do your part by seeking to avail yourselves to the uttermost of any such opportunities provided," and it might be added that the reason why that future "important commercial rival, Japan, is developing its manufacturing powers with an energy that is as remarkable as it is unexampled" is because even thirty years ago its young students absorbed with eagerness and rapt attention every scrap of scientific teaching which they could obtain. And they did so partly for their own personal benefit, but far more because each one felt that on his own exertions depended the fame and future of his mother country.

W. E. A.

RESEARCH WORK AND THE OPENING OF THE MEDICAL SCHOOLS.

IN one sense at least, viz. his intellectual life, the medical student, natural enough in other respects, seems somewhat at variance with nature; his intellectual spring occurs simultaneously with nature's autumn. Brown October sees him change the abstractness of the class-room for the concreteness of the laboratory. Further, each successive autumn, after a period of summer hibernation, marks the advent of some change in his studies. The fully fledged doctor, too, whose daily round obliterates all distinction between term time and vacation, becomes infected in October with a revival of intellectuality, and whets his appetite by an attendance at the inaugural address delivered at his school, where he gets new knowledge or old dished-up afresh, and becomes generally imbued with the spirit of the time.

This year at least the medical student will not be able to lay any shortcomings which may occur during the ensuing academical year to the charge of insufficient or inadequate advice at its onset. At both the London and provincial schools the inaugural addresses, with regard to depth of meaning and also attractive eloquence, have left little to be desired.

In a short article such as the present it would be impossible to adequately reproduce, even in the most abridged form, the various "motifs" pervading the speeches delivered. One, however, constantly recurring, may be somewhat enlarged upon. Here and there and everywhere in the inaugural addresses we find the position of research to medicine and the medical profession cropping up. Occasionally this subject is mooted in the grossly material form, when, for instance, Sir James Crichton Brown frankly told his hearers at Manchester that although 70,000*l*. was an adequate sum so far

Manchester must be prepared to put its hand in its well-lined pocket for an equal amount to keep pace with science, which is now so mobile and so expensive. Dr. Clifford Allbutt delivered an address at St. Thomas's, which mostly consisted of a strictly logical defence of theory and abstract learning. Those who read carefully Dr. Allbutt's address will find more in it even than this. The apostles of empiricism, to whom the almighty fact is alone of importance, are the worst enemies of what may collectively be termed medical research. Their bourgeois utilitarianism prevents them from appreciating or forwarding any branch of inquiry connected with the medical sciences which does not immediately result in something of use. Research to them is the quintessence of an abstractitude.

This mental attitude of a part of the profession, which fortunately is getting less and less, finds its expression in the position adopted by the influential public and lay committees. It is somewhat anomalous—at any rate, it appears so—that astute financiers, practical men accustomed to weigh the chances of ultimate dividends in the most complicated concerns, should so discount pathological and pharmacological research. It must be known to them that a large proportion of the drugs they take, and the curative remedies they employ, are made in Germany, and that thousands of pounds are spent annually on German products of this class which might perfectly well be produced at home. Those of them who wander so far from the Stock Exchange as St. Dunstan's Hill will find there a whole colony of German firms which supply these articles. A public which will wait for years for dividends so far as concerns South African securities, which will fill up readily the gaps in a Cape to Cairo railway scheme, although this at present can only be done by a somewhat lively imagination, is inclined to push and accelerate the scientific worker, and expect maximum results in minimum time. The success of the German manufacturer in products such as therapeutic sera and synthetic drugs is simply due to the fact that the German capitalist has waited for his dividends which he is now getting. Apart from the standpoint of mere commerce, it is somewhat galling to know that a crude product like coal-tar is at present exported from this country, and re-imported worked up in the shape of dye-stuffs and drugs.

To work one must have a workshop; a palace one does not need. This forms another great difficulty with regard to medical research in London. The authorities at the London hospitals rightly regard the patients as having the first charge upon the space and accommodation at their command. Space in London, especially so far as concerns the older foundations—such, for instance, as St. Bartholomew's and Guy's—is necessarily very valuable. This subject formed the keynote of some of the speeches at the old students' annual dinner at St. Bartholomew's. The Great Hall was full of old Bartholomew's men, who, under the chairmanship of Dr. Lauder Brunton and the secretaryship of Mr. Bruce Clarke, met to inaugurate the new academic year. Dr. Lauder Brunton, in a short but effective speech, proudly stated that the hospital, so far as its essentially medical aspect went, left nothing to be desired; quite so much, however, could not be said for the laboratory accommodation. Sir Norman Lockyer, whose opinion upon the subject of experimental technique ought certainly to be final, also deplored this want of laboratory space in so old and famous a medical school. Many difficulties special to medical research were discussed by Sir Norman, and research in this branch of knowledge was compared to research in the physical sciences. One of the difficulties was the question of time. The worker in the fields of the medical sciences must solve his problems often at once. He must be an opportunist. Stars and planets remained more or less the same, but this was not so with disease. Pressure from without, according to Hunter, causes hypertrophy or overgrowth, pressure from within atrophy or waste. If the pharmacological laboratory at St. Bartholomew's is not in a condition of healthy overgrowth, it is certainly not because pressure from without is wanting, for, according to Dr. Brunton, its confines have been narrowed down to some fourteen square feet. It was reassuring to be informed by the treasurer, Sir Trevor Lawrence, that arrangements were on foot which would ensure more ample accommodation to laboratory workers at Bartholomew's.

The London Hospital was fortunate in securing the presence of Dr. Haffkine, who made an excellent and humorous speech. The St. George's students were addressed by Dr. Howship Dickinson upon "Medicine Old and New." Dr. Mitchell Bruce, at Charing Cross, took the "Outlook of Medicine" as the subject of his address. This was, he said, at the present time hopeful, since the scientific method was being pursued in every department of medicine.

In laying stress upon the special difficulties of the time, one is perhaps rather apt to forget the causative origin of all the inaugural addresses, viz. the medical student himself. He comes in ample numbers, a sufficient testimony to the healthiness of the profession he aspires to join, from year to year, sometimes partially prepared by the universities, sometimes raw from school, to struggle with those life-long difficulties of the healing art, compared to which even examinations count as nothing. For five years, now, he must suffer many things of divers examiners, and finally emerge to meet the great problem of his life—the human individual, both healthy and diseased. Exact knowledge in the sense of physical exactitude will probably be denied to as yet many generations of medical students, even concerning the main problems of disease, and in spite of the progress that, thanks mostly to careful and continual laboratory work, often of an apparently abstract nature, has during the last century been made, our knowledge even now serves often merely to illuminate our ignorance, and however optimistic our hopes for the future we are forced to admit that—

A thousand things are hidden still,
And not a hundred known.

F. W. T.

DARK LIGHTNING FLASHES.

IS there such a phenomenon as dark lightning? This is a question that has often been raised, and as yet no satisfactory answer has been given. If dark flashes do really occur, then they should probably be both seen and photographed, and the former, one would think, would be the more simple way of recording them. A difficulty, however, here arises, for if we assume that both dark and bright flashes occur during a thunderstorm, then we must be careful not to mistake retina-fatigue dark flashes for actual dark flashes if they exist. Lord Kelvin (NATURE, vol. lx. p. 341) has lately pointed out how, during a recent storm, he was able to confirm the existence of these *apparent* dark flashes; and in a more recent number of this journal (vol. lx. p. 391) I published some observations corroborating the same view. It must be pointed out, however, that, although such observations indicate that the majority of dark flashes seen may be attributed to the cause of fatigue of the retina, it does not necessarily follow that dark flashes do not actually occur. Eye observations, therefore, do not help us as yet to give a satisfactory answer to this question.

Let us turn now to photography, and see what evidence we can gather from photographs of flashes taken during thunderstorms.

In dealing with this mode of recording flashes, we are again confronted with many difficulties, for the action of light on the sensitive film is capable of giving us both bright and dark images, although the object photographed is bright. We have, therefore, to contend with reversals, double reversals, &c., and many as yet unknown factors.

There is one point, however, that stands out foremost, and that is that the photographic plate has recorded many times dark as well as bright flashes; but whether the dark flashes are due simply to some action relative to the sensitive film, or are actual images of real dark flashes, is the very question that has so recently been revived.

What we really are greatly in need of is more data, and when a sufficient number of photographs of all kinds of lightning has been collected, more light will be thrown on this subject. Up to the present time, as each curious photograph of dark lightning was published, suggested theories as to the cause of the peculiarity of the flash have been by no means few in number, so that now the number of hypotheses equals, if not exceeds, that of the photographs examined.

In a very interesting article in this journal (vol. xlii. p. 151), which is an extract from a lecture on "Electrical Phenomena in Nature," delivered by Mr. Shelford Bidwell at the London Institution, the so-called "dark flash" is referred to in these terms.

"It occasionally happens that, on developing a photographic plate which has been exposed during a thunderstorm, the image of a lightning flash comes out black instead of white. . . . There is no need to discuss the several ingenious hypotheses which were suggested in explanation of the anomaly; it is sufficient to say that the mystery was completely cleared up a few months ago by the experiments of Mr. Clayden."

As I have no reference to Mr. Clayden's experiments at hand, I will quote from the above-mentioned abstract a brief summary of his hypothesis as described by the same writer.

"If the lens of the camera be covered the moment after a flash has occurred the developed image will always come out bright, feebly or strongly, according to circumstances. If, however, the plate be exposed after a flash has acted upon it, either to the continued action of a feeble diffused light or to the powerful glare arising from one or more subsequent flashes, then on development the image of the original flash will probably come out black. The effect is therefore not a meteorological or physical one, but purely chemical. It can be obtained, not only with a lightning flash, but also with a machine spark, or even with an ordinary flame. It is merely necessary that the plate should be exposed to the action of a certain amount of light after it has received the impression and before development."

At the present time Mr. Clayden's explanation may be looked upon as the most reasonable working hypothesis for future use. There is one crucial test which can be tried, which would settle once and for all its value. Unfortunately, so far as I am aware, this test has not yet been made, and I propose (and I hope others will as well) under the next suitable conditions to make the attempt. It is simply this. Take two cameras, say A and B, and orient them both in the same direction towards the point where the same flashes will come in both fields of view. Expose A for say fifteen minutes to record all the flashes that occur during that interval (some of these on development should be *bright*, some *dark*). Expose B for one flash only, preferably the first bright one which occurs during the exposure of A; this should develop *bright*. Compare the same flash on both negatives; that in A should be dark, that in B bright. If this be not the case, then I think the hypothesis breaks down. Perhaps this experiment may not be so easy to perform as it at first appears, for the difficulty lies in being able to catch one strong flash without exposing the plate to any light from other flashes which illuminate the sky, but are not in the field of view themselves. Several attempts by numerous observers would probably give us the information required.

With the object of firstly contributing data towards the interpretation of this curious and interesting phenomenon as recorded by the sensitive film, I give here some illustrations from absolutely untouched negatives of

FIG. 1.—Lightning flashes taken during a thunderstorm at Göttingen, Germany, in 1893.

lightning flashes. All these reproductions are reduced about one-third.

I may perhaps preface my descriptions of the photographs by the remark that, having always taken a great interest in procuring lightning flashes by the aid of the camera, I have never, until this year, been fortunate enough in securing records of dark flashes. I have always previously exposed my plates or films for periods of fifteen minutes or more, depending on the strength and nearness of the storm. This fact at first suggested to me the idea that dark flashes might after all be real, but

FIG. 2.—Showing dark (A and B) and bright (C and D) flashes photographed at Westgate-on-Sea on August 5, 1899.

restricted to certain kinds of storms, the special peculiarities of which I cannot state.

Fig. 1 is a type of several negatives I have secured previous to this year, and although the exposure was twenty-five minutes in length, an examination of the negative shows absolutely no trace of any *dark* flash. The photograph, which was taken at Göttingen in North Germany, is interesting on account of the fine flash (A) which is traversing the air in a nearly horizontal direction and without any branches or ramifications. In the right-hand corner will be noticed numerous flashes from clouds a great distance away.

I will now describe three of the four photographs I secured during the storm that passed over Westgate-on-Sea, Thanet, during the night of August 5 of this year (see letter, NATURE, vol. lx. p. 391); all four show

FIG. 3.—Showing bright (B and D) and dark (A and C) flashes photographed at Westgate-on-Sea, on August 5, 1899.

dark as well as bright flashes. The camera employed was one of those excellent and handy little 5 × 4 daylight folding Kodaks, and the exposure in each case was fifteen minutes. The storm, I may add, passed roughly from S.E. towards N.W., and my camera was placed on a window-sill facing due north.

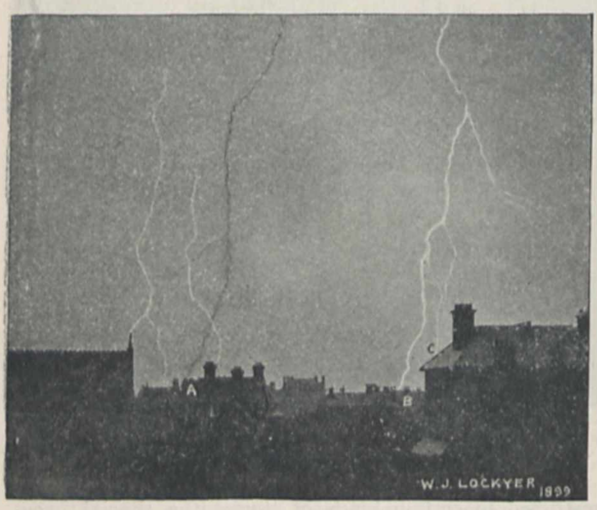

FIG. 4.—Showing bright (B and C) and dark (A) flashes photographed at Westgate-on-Sea, on August 5, 1899.

Fig. 2, showing the north-western sky, displays several flashes, the most prominent of which are C and D bright and A and B dark. The bright flashes have no ramifications, while the dark distinct flash A has several dark. It may be that B is only a large ramification of A, but it is difficult to say.

Fig. 3. The northern sky as here shown displays four prominent flashes, A and C dark and B and D bright. B, as will be noticed, appears to take a very circuitous path, which resembles very closely that illustrated in a previous number of NATURE (vol. xlii. p. 152), and which was a reproduction from a photograph taken on June 6, 1889, by Mr. Rose at Cambridge.

The last, and, I think, absolutely unique photograph of

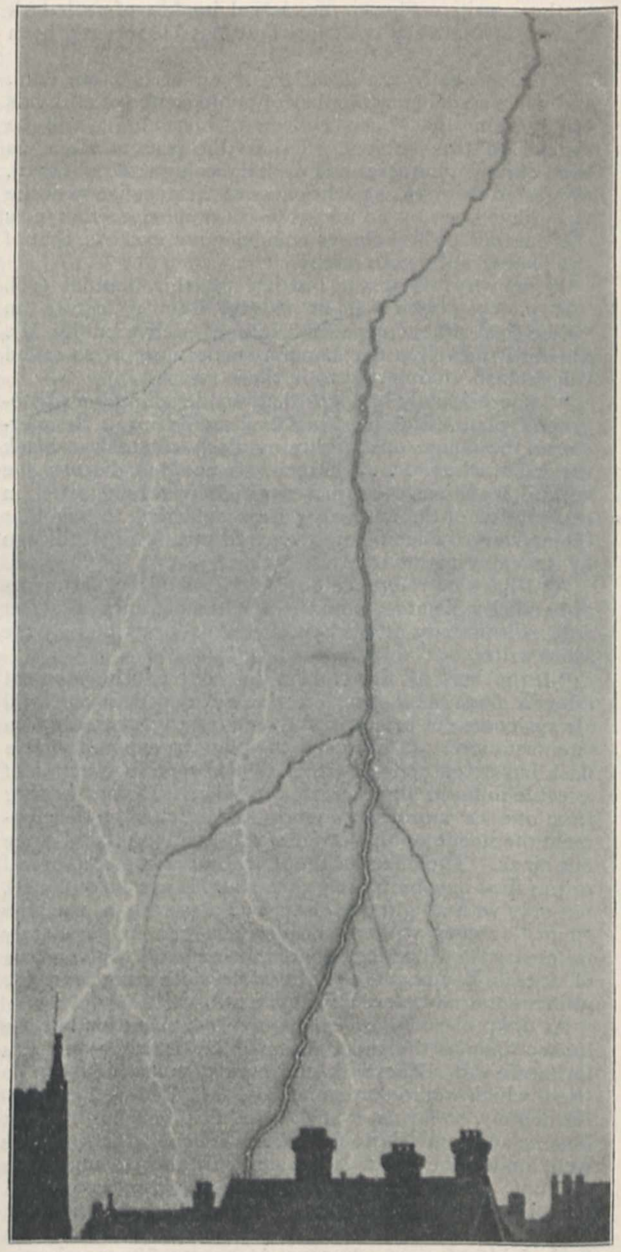

FIG. 5.—Enlargement of dark flash A in Fig. 4.

a dark flash, is illustrated in Fig. 4. The negative was exposed when the storm was perhaps just a little north of my position (camera pointing due north). The two most prominent flashes are those marked A and B. B is the ordinary bright flash with numerous bright ramifications, while A is also equally, if not more, strong but *dark* with *dark* ramifications. An enlargement of this flash is shown in Fig. 5. Most interesting, however, is the *reversal*, which extends nearly the whole way up the centre—that is, the dark flash has along its centre a bright core. It is this very photograph which made me cast doubt on the hypothesis suggested by Mr. Clayden, for both a very strong flash can be recorded *very* dark (with a reversal), and also a weak flash (see Fig. 2, B). If the reader refers to an interesting article on "Lightning," by Mr. Jeremy Broome, that appeared in the January number of the *Strand Magazine* in 1897, there will be found a reproduction of a photograph taken at Cambridge by Messrs. Valentine Blanchard and Lunn, showing a *bright* flash with a *dark* reversal down the centre, the exact opposite to the flash recorded above. It may be remarked that a reversal is perfectly distinct from a double flash, many of which have been recorded.

Another flash of interest and peculiarity is that marked C. This flash is quite distinct from B, but unlike all the other bright flashes of about the same intensity, which are clear and sharply defined, this one is occasionally split up along its path into two parts, and the *flash on both sides throughout its whole length is bounded with dark borders.* Both the original negative and a silver print show this peculiarity distinctly, but unfortunately the dark borders are lost in the reproduction. I find that this peculiarity about a flash has been photographed before, but apparently not noticed. If the reader will refer to an old number of *Knowledge* (vol. xviii. p. 224), he will find a reproduction of a lightning flash taken by Mr. George Primavesi at Tooting. This flash is far more intense than that on my negative, and the dark borders are more developed. The main stream is devoid of ramifications: the exposure lasted for only one second.

To sum up, then, the different appearances of the lightning flashes recorded in these photographs, and others of which I possess either photographs or reproductions; we have the following various kinds:—

Main stream.	Ramifications.	Reversal down centre.	Source of information.
Bright	None		Fig. 1, A
,,	Bright		Fig. 4, B
,,	Dark		NATURE, vol. lx. p. 423
,,	None	Dark	*Strand Magazine*, Jan. 1897, p. 41
,,	Bright	Dark	?
,,	Dark	Dark	?
Dark	None		Fig. 3, A
,,	Dark		Fig. 2, A
,,	Bright		?
,,	None	Bright	?
,,	Dark	Bright	Fig. 4, A
,,	Bright	Bright	?

The peculiar flash marked C in Fig. 4 I have not inserted in the above table, as it is difficult to decide under which category it should be placed.

Now in attempting to explain the cause of dark lightning I employed Mr. Clayden's idea as a working hypothesis, but I can find no reference to any illustrations of the experiments he carried out. Mr. Shelford Bidwell, however (NATURE, vol. xlii. p. 153), describes and illustrates one out of a series of experiments he made, and this shows dark and bright flashes made artificially, but the flashes are simply dark or bright, with no other peculiarities.

Further, in a letter which appeared in a very recent issue of this journal, Mr. F. H. Glew mentions that he also has made several experiments with regard to the Clayden effect. The illustration which accompanies his account of these investigations (the *Photographic Journal*, vol. xxiii. No. 7, p. 179) shows, like Mr. Bidwell's, no more than simple dark and bright flashes. I may here mention that the method described by me further on was not very dissimilar to that employed by Mr. Glew, although I was unaware until quite recently of the publication of his to which reference has just been made.

Now the point most interesting to me was, Could one artificially produce on one plate or film *exact* types of dark and bright flashes as shown in the above illustrations; that is, flashes which are dark with *bright cores* and bright with *dark borders?* No photographs of sparks produced artificially have, so far as I know, displayed any of these peculiarities.

I will simply describe one experiment that I made, with this object in view, in the laboratory of the Solar Physics Observatory, Kensington.

To produce the spark I employed a 10-inch Apps' coil, with a pint jar in circuit, fed by two cells of four volts each, the sparking distance being two inches. The camera was a small 5 × 4 by Herr Winkel of Göttingen, fitted with a Zeiss objective. Although it was made only

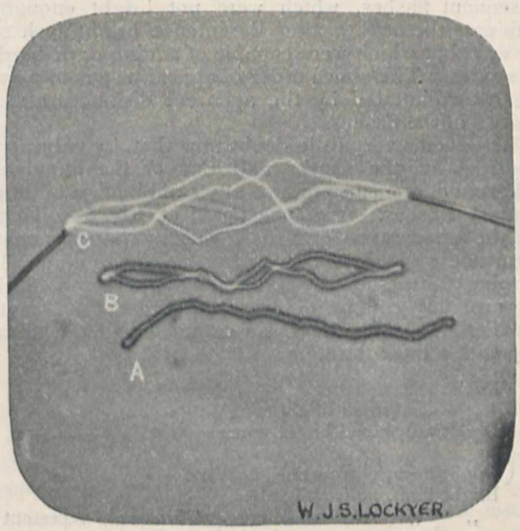

FIG. 6.—Showing three series of sparks taken on one plate against a white background. During the passage of the sparks at C, the background was artificially illuminated.

for the use of glass plates, by a simple device Eastman's film could be employed. Films, I may mention, eliminate all chances of halation.

The method of procedure was as follows:—

In a darkened room I first of all made an exposure on a *single* (2-inch) spark against a bright (white cardboard) background. On development this bright flash came out naturally *bright*.

I next inserted a new film and repeated the same experiment, except that I did not remove the film or develop it immediately. Covering up the lens carefully, I moved the poles in a vertical plane so that the next spark should fall on a different part of the film, and made a second exposure on two sparks. Again covering the lens, and moving the poles a little in the same direction, I exposed the film once more to a series of four sparks, *but while I allowed the sparks to pass I illuminated the cardboard background by burning one inch of magnesium ribbon at a distance of two feet.*

It may be mentioned that the poles only appear on the negative in their respective positions when the background is artificially illuminated. Fig 6 shows the results obtained. A is the first spark, B the two sparks after the first movement of the poles, and C the last four flashes when the background was artificially illuminated.

A close examination of the figure shows that, not only do we get types of simple bright flashes, but we obtain dark flashes with bright cores and bright flashes with dark boundaries.

Now A (Fig. 6) is exactly similar in type to the dark flash in Fig. 4, A, while the two bright flashes in C correspond also to the bright flashes in Fig. 6.

The peculiar flash at C (Fig. 4) is an exact counterpart of D in Fig. 5.

This experiment leads me to conclude, therefore, that Mr. Clayden's hypothesis is entirely corroborated, and explains very satisfactorily the types of flashes illustrated in the above reproductions from photographs.

In studying Fig. 4 in the light of these results, we can form a good idea of the order of appearance of the flashes. That marked A was undoubtedly the first to occur (if the plate had been immediately developed, it would have come out bright); then the flash B made its appearance, and, being so intense, illuminated the neighbouring region round A that the image of A on the film was affected chemically. C was probably next in order of occurrence, but, being more distant and therefore fainter, did not have any effect on A or B. C, however, was affected by subsequent flashes, which were not bright enough to illuminate the field to alter the intense bright flash B in any way, but which were capable of adding dark borders to its sides. The above order of appearance is to a great extent corroborated by the apparent distances and intensities of the flashes.

There seems very little doubt now that, by varying the intensities of the sparks and that of the illuminated background, one can produce any combination of bright and dark flashes. A glance again at Fig. 6 will show that the appearance of a flash depends simply on the magnitude and presence or absence of the core. The following table sums up the six chief types of flashes that probably can be obtained: the reader will notice that there is a complete cycle commencing and terminating with a dark flash.

1. Dark flash, no core.
2. ,, ,, small bright core.
3. Dark flash, broad bright core; or, Bright flash, narrow dark borders.
4. Bright flash, *no* dark borders.
5. ,, ,, small dark core. This would represent an ordinary weak reversal.
6. Bright flash, broad dark core; or, Dark flash, narrow bright borders. This would represent an ordinary strong reversal.
7. Dark flash, *no* bright borders; or, same as No. 1 above.

In the above list photographs have *actually* been obtained of all the types of flashes that came under the headings 1–5. I have examined all my *negatives* to search for the type No. 6, with the result that I have not found a representation of this kind of flash.

It may be remarked that the types 1–3 are produced as a direct consequence of the Clayden effect, and should therefore only appear on plates which contain more than one flash. The other types, which depend simply on the intensity of the flash, should be obtained when even only one flash appears on a plate.

We thus see that actual photographs of lightning bear out what we should expect from laboratory experiments, and we must therefore answer in the negative the question asked in the first line of this article.

Dark lightning flashes therefore do not exist in nature, but their appearances on photographs are due to some chemical action which takes place in the gelatine film.

In closing this article I wish to draw attention to the great interest which is attached to this most fascinating subject. Every one who has a camera can help in the elucidation of the several points to be studied, and most probably bring new facts to light. The photography of lightning flashes during the night is an easy subject, for one has simply to turn the camera towards the dark sky, and the lightning does all the exposing itself. Unfortunately it is not every one who is aware of this fact, and I know of two instances of amateurs who exposed plates during the same storm and at the same place where I obtained the above pictures, but they tried to *catch the flashes by using instantaneous shutters*. Whether they obtained any positive results I do not know, but one could make a very fair guess.

If any readers of this article would be willing to exchange interesting unmounted lightning photographs obtained by them for copies of any of the above illustrations from the original negatives, the writer would esteem it a favour. (Address: 16 Penywern Road, South Kensington, S.W.) This request suggests to me that it would be important for the furtherance and development of this subject, if there were some recognised "Central-Stelle" to which copies of all such photographs could be sent. Those studying the subject would not then be so much hampered in searching for references to accounts of original observations and reproductions, if a fairly complete collection of copies from original negatives were made accessible. WILLIAM J. S. LOCKYER.

NOTES.

PROF. A. GRAY, F.R.S., Professor of Physics in the University College of North Wales, has been appointed to succeed Lord Kelvin in the chair of Natural Philosophy in the University of Glasgow, and will at once commence his new duties.

THE Harveian Oration will be delivered at the Royal College of Physicians, London, on October 18, by Dr. G. Vivian Poore, and the Bradshaw Lecture on November 2, by Dr. A. Foxwell.

MAJOR RONALD ROSS and other members of the Liverpool Malaria Expedition have returned to this country very well satisfied with their labours. On the advice of the expedition the authorities at Sierra Leone decided to use every means to exterminate the malaria-spreading mosquito. Major Ross is of opinion that the white population is not careful enough, and that the houses are badly constructed, and compare unfavourably with the residences of white people in India, which are constructed on plans that give the inhabitants every chance of health, despite the tropical climate. He attaches great importance to this question of the construction and situation of the houses. Dr. Fielding Ould, a member of the expedition, has remained behind to consult with the medical officers on the coast respecting measures to be taken for the extermination of the malarial mosquito in the neighbourhood of the principal towns. During the investigation one member of the expedition, Mr. Austin, suffered from malaria; he became infected through sleeping one night without the protection of mosquito curtains.

DRS. CALMETTE AND SALEMBENI, who were sent out by the Pasteur Institute as a commission to study and combat the plague in Oporto, have returned to Paris more than satisfied, it is said, with the success attending their efforts with the anti-plague serum. Dr. Calmette is of opinion that the Portuguese might easily free themselves from plague if they would rigorously carry out the measures which have been recommended to them, and in particular if they would inoculate all the inhabitants of suspected quarters. This, however, they appear unwilling to do.

ACCORDING to the *Civil and Military Gazette*, Lahore, the Indian Government has under its consideration a somewhat comprehensive scheme for the establishment of research laboratories in various parts of India, and the appointment of health officers to the charge of them. The present laboratory at Muktesar will, it is understood, be further developed, and the staff increased, the establishment becoming the central research laboratory for India, and health officers will be appointed to the charge of laboratories at Calcutta, Madras, Bombay, Agra and Lahore, the new department of bacteriology being ordinarily manned by officers of the Indian Medical Service.

DR. CARL PETERS has, it is stated by Reuter, left Portuguese territory and crossed into Mashonaland. Part of his expedition has, however, been left in the neighbourhood of the ancient ruins re-discovered by him near the Zambesi. Dr. Peters' intention is reported to be the establishment of a permanent station on the Inyanga Highlands, and to explore from that point the whole of Mashonaland from north to south. The explorer claims to have discovered mica, saltpetre and diamonds in a district practically uninhabited, at an altitude of 8000 feet, and, he believes, easily capable of cultivation. As the rainy season is now setting in Dr. Peters will, after exploring some districts on the Pungwe River, proceed to Beira *en route* for England.

WE regret to have to record the death, at the age of fifty-eight, of Mr. John Donaldson, a partner of the engineering firm of Thornycroft, which took place last week. Mr. Donaldson had much to do with the introduction of fast torpedo boats into the British Navy, and was a great believer in his firm's water-tube boiler. He was a member of the Institution of Civil Engineers, the Institution of Naval Architects and the Institution of Mechanical Engineers.

Science announces the death, at the age of eighty-four, of Chief Justice C. P. Daly, who for many years took a deep interest in scientific matters, particularly in the branches of geography and botany. Mr. Daly was for thirty-six years president of the American Geographical Society, and was largely instrumental in founding the Society's extensive library, and in securing the endowment of its new building. He also rendered good service to the Botanical Garden of New York, and was one of its managers.

MONUMENTS in memory of Siemens and Krupp will be unveiled at Charlottenburg on the 19th inst., the occasion being the centenary of the Technical Institute of that town.

IT having been decided by a number of friends and pupils of the late Dr. Friedel to place a bust and enlarged photograph of him in the hall of the Sorbonne, a circular asking for subscriptions has been distributed. The bust will be the work of M. Uitain, who executed that of Schutzenberger, and is estimated to cost 3000 francs. Subscriptions should be sent to M. Chason, at the Laboratory of Organic Chemistry, Faculty of Science, the Sorbonne.

THE highest observatory in Germany is now completed. It is situated on the Schnee Koppe, the highest summit of the Silesian Mountains, at an elevation of 5216 feet. It will be managed as an institution of the Prussian State.

MR. W. D. HUNTER, special agent of the Division of Entomology, Department of Agriculture, has, says *Science*, returned to Washington, after having studied the Turtle Mountain region in North Dakota and Manitoba, supposed to be a permanent breeding-ground of the Rocky Mountain locust. This, it is reported, he found not to be the case, and he thinks that the probable breeding-ground is the Assiniboine River, north and east of Regina, a region that will be investigated next season.

ACCORDING to *Nature Notes*, a circular has just been issued to all Catholic missionaries by the Sacred Congregation of the Propagation of the Faith, urging them to use such opportunities as the locality of their mission work affords for the collection of natural history specimens, to be given to scientific societies and institutions. The intention, it is asserted, is not only to interest and encourage such missionaries as are keen naturalists, but also to remove the reproach so commonly held that the Church does not look with favour upon science, and especially biological science.

THERE being much difference of opinion as to the kind of ration best adapted for soldiers and sailors in tropical climates, a prize of 100 dollars, or a medal of that value, as the successful competitor may select, has, says the New York correspondent of the *Lancet*, been offered by Dr. Louis L. Seaman for the best thesis on the subject, viz. "The Ideal Ration for an Army in the Tropics." The competition is open to all commissioned medical officers of the U.S. army and navy, regular and volunteer. The prize is offered through the "Military Service Institution of the United States." The executive council of that body has decided that all papers should be submitted by March 1, 1900.

THE joint committee of the Glamorgan County Council and Cardiff Corporation invite applications for the post of bacteriologist and lecturer, to work under the direction of the medical officers of health of the borough and county. Full particulars as to the duties and emoluments of the office will be found in our advertisement columns.

THE American Mathematical Society, which was established on its present basis so recently as 1894, appears to be in a flourishing condition. Its membership is now over three hundred, and at its recent summer meeting, held at Columbus, Ohio, simultaneously with that of the American Association, no fewer than twenty-four papers were read.

IN the address delivered at the opening of the winter session of the Jenner Institute of Preventive Medicine, on Monday last, Dr. Macfadyen gave an account of the institute and its work. In the course of his remarks he said the Anti-toxin Department was engaged in preparing various therapeutic serums, notably the anti-diphtheritic serum, as well as in research in this important field of work. The primary object of the institute was research, but facilities were afforded for post-graduate instruction in preventive medicine and bacteriology. The students had come from all parts of the world, and a considerable amount of original work had been done by those trained in the laboratories. Investigations were at present being made at the institute with reference to the possible cure or prevention of typhoid fever, tuberculosis and other diseases. The diagnosis of infectious diseases was constantly being carried out for the main parishes of London, as well as the investigation of questions affecting the public health on behalf of sanitary authorities. The chemical and State medicine laboratories would find much to do in connection with water, sewage, food, poisons, &c. A notable addition had been made to the resources of the institute in the Hansen Laboratory for the study of the practical application of bacteriology to industrial and technical processes, and the most important results might be anticipated in the future from this branch of investigation.

THE New York *Electrical Review* gives particulars of a recently invented electrical and chemical fire-alarm apparatus, which gives its indications when the atmosphere becomes so vitiated with smoke that it will not support the combustion of a gas flame. In the interior of the apparatus a small gas flame constantly warms a thermostatic bar, the electric circuit through the apparatus being normally open as long as the flame holds out to burn. If the air in the apartment in which the apparatus is installed becomes vitiated with smoke, the little gas flame goes out, and the thermostatic bar, cooling off, closes the circuit and gives the alarm.

At the International Fishery Congress held at Bergen in 1898, and at that held at Dieppe, an effort was made to start the publication of an "International Review of Fisheries and Fish Culture," which should serve to maintain constant relations between specialists of this branch of science working in different countries. Such efforts were, however, unsuccessful so far as a favourable decision of the Congresses being arrived at was concerned. This being so, and the want of such an organ being considered a very real one, the Russian Imperial Society of Fish Culture and Fisheries has undertaken the publication of such a periodical as has been mentioned, to contain articles in German, French and English. The first number, dated August, has just reached us and contains many interesting contributions, among which may be mentioned "A Short Comparison between the Caspian and the Baltic Seas," "Short Notices of the Fisheries of Sweden," "Fish Culture in the United States," "Contributions to the Study of Fishing Apparatus." The following programme will give an idea as to the scope of the new journal, which has made a very creditable beginning:—New facts pertaining to fish- and oyster-culture (statistics, new methods used in fish-culture, inventions, &c.). New facts and data pertaining to fisheries (statistics, fishing news, inventions, new laws, &c.). Professional education of fishermen and of workmen engaged in the manufacture of preserved fish. Novelties in the manufacture of fish products (new patents, new canneries, &c.). Improvements in the fish-trade and in the methods of carrying fish (fish-markets, cold-storage houses, refrigerator-cars; new duties on imported fish). The work of fishery-societies. Review of scientific investigations connected with fisheries. New books on fish-culture and fishing. Personal notes.

IN a recent number of the Paris *Comptes rendus* (vol. cxxix. p. 417), M. L. Teisserenc de Bort contributes some interesting particulars relating to the temperature of the free air and its variations from observations obtained from ninety unmanned balloons, sent up from his observatory at Trappes since April 1898. The observations have been spread over every month; seven of the ascents exceeded 14,000 metres, twenty-four 13,000 metres, and fifty-three attained a height of 9000 metres. The discussion of the observations exhibits the following general results: (1) The temperature at various heights presents during the course of the year important and greater variations than have been admitted from older series of observations made in manned balloons. The temperature of 0° C. is found at very different altitudes, varying from the level of the ground in winter to above 4000 metres in summer. The isotherm of −25° C. is met with about 3000 metres in winter and above 7000 m. in summer; in September it was observed even above 8000 m. The isotherm of −40° C. was several times found as low as 6000 m., and is generally met with about 9000 m. and even higher towards the end of summer. The temperature of −50° C. has never been recorded below 8000 m.; its greatest altitude was at 12,000 m. (2) There appears to be a marked tendency to an annual variation of temperature even up to 10,000 m., the maximum being about the end of the summer, and the minimum near the end of the winter. The observations given in a table appended to the paper do not show such a rapid variability with height as has been generally supposed; it appears, further, to vary with the type of weather.

IN the *Atti dei Lincei* viii. (2) 4, Dr. D. Lo. Monaco and L. Panichi give a second note on the action of quinine on the parasite of malaria. The most remarkable result is the effect of solutions of strengths lying between certain limits in provoking the exit of the parasites from the red corpuscles, when the parasites are in the second or adult stage. The authors now find that the action of quinine on the endoglobular parasites of spring fever may be thus summed up: (1) in very dilute solutions it excites them; (2) in less dilute solutions the excitement, which reaches its maximum phase in the exit of the parasite from the red corpuscle, is preceded by a brief contraction; (3) in strong or concentrated solutions it paralyses them. There is still some doubt as to the dose of quinine which should be administered in order to effect a cure, and this probably varies in different patients; but it appears that the doses commonly adopted must be regarded as excessive, and that the rational dose suited for curing an attack of spring fever is comprised between half a gramme and a gramme of bisulphate of quinine.

THE *Sitzungsberichte der physikalisch medicinischen Societät* (Erlangen) contains abstracts of several experiments on kathodic rays. The first of these, by Prof. E. Wiedemann and A. Wehnelt, is a simple proof that while kathodic rays are deflected by a magnet, the Goldstein rays are not directly influenced by magnetic force. In the second note the same authors deal with the question of the repulsion of converging kathodic rays, and describe experiments showing that the rays emanating from a hollow kathode cut one another, and that this result is not inconsistent with Weber's experiments. The third note deals with the variations in the potential of discharge in the kathodic dark space, and their independence of ultra-violet or Röntgen rays. Prof. E. Wiedemann contributes a further note on the "simple" kathodic rays of Deslandres. M. Arnold discusses the influence of the luminosity of the anti-kathode on the emission of Röntgen rays; and A. Moffatt gives an interesting note showing that the power of Röntgen rays (*i.e.* their energy divided by the time) is greater than is commonly supposed, and may be about 1 to 10 calories per second.

THE Calabro-Messinese earthquake of November 16, 1894, occupies a prominent place among recent Italian shocks. A Government commission was immediately appointed to study it, but, for various reasons, the complete report has not yet been published. Prof. Riccò, however, has contributed a summary of the seismological section to the Royal Accademia dei Lincei (*Rendiconti*, vol. viii. pp. 3-12, 35-45), and has illustrated it by a map showing the isoseismal lines of the principal shocks of 1894 and 1783. The meizoseismal area of the earthquake of 1894 is situated about twenty miles north-east of Reggio, and the isoseismal lines (which depend, however, on observations from only 170 places) are roughly concentric with this area, but they expand towards the north-west, and are rather crowded together towards the south-east. As a general rule, they follow the boundaries of the great crystalline masses. The total disturbed area (included within the isoseismal 2) is about 44,000 square miles. Nearly a thousand houses were completely destroyed, and more than 44,000 were damaged; about a hundred persons were killed, and a thousand wounded. The earthquake was registered by seismographs at seven Italian observatories, and by the horizontal pendulum at Nicolaiew. A puteometer at Catania indicated a sudden rise of 17 mm. in the well-water, followed by a fall of 14 mm., after which the surface returned nearly to its original position. The mean surface-velocity of the larger vibrations in Italy was almost exactly 2 km. per second; but it varied with the distance, for the hodograph (see NATURE, vol. lii. p. 632) is at first convex to the axis of the distance and afterwards concave. Prof. Riccò remarks that the earthquake of 1894 may be regarded as an after-shock of the great earthquake of 1783, its epicentre being displaced slightly to the south-west; but its intensity was much less, for the meizoseismal area (that bounded by the isoseismal 10) is only one-sixth of that of the earthquake of 1783.

THE department of vertebrate palæontology of the American Museum of Natural History reports that in 1898 the second expedition for Dinosaurs was sent out to Wyoming in charge of Dr. J. L. Wortman, with a party of four. Deposits of Dinosaur bones very favourably situated were found. In all some 60,000 pounds of fossils were secured. This splendid collection reached the museum entirely uninjured, and one-third of it has already been worked out. The fore and hind limbs of these monster reptiles will furnish subjects of great interest for the public. The exhibition hall has been enriched by the skeletons of two great Dinosaurs. A second party, under the direction of Dr. W. D. Matthew, was at work in 1898 in the fossil beds of north-western Kansas and south-western Nebraska. The Bad Lands of north-eastern Colorado were also found to be a rich collecting-ground. Skulls and parts of skeletons were secured, filling many important gaps in the Museum collection. Portions of skeletons and skulls of fossil camels were found, among which is included a gigantic one of the size and proportions of the giraffe. The party also acquired a large amount of other material. It is a little surprising to notice that, though the museum is doing so much to promote educational and scientific advancement in New York, the income in 1898 was insufficient to meet current expenses.

THE monograph, "The Later Extinct Floras of the United States," left unfinished by the death of Prof. Newberry, is to be completed by Dr. Arthur Hollick.

THE Essex Technical Instruction Committee have issued, through the County Technical Laboratories, Chelmsford, a report, compiled by Mr. T. S. Dymond, of a visit paid to Holland by Essex agriculturists in May and June of the present year. The report is interesting reading, and gives a brief outline of the more prominent features of Dutch farming. A perusal of the pamphlet will supply English agriculturists with a few hints which in some cases might with advantage be acted upon in this country.

THE report of the Connecticut Agricultural Experiment Station for 1898 has just been published, and is full of valuable matter. Several of the reports contained in the volume should be of interest and service, not only to inhabitants of the State of Connecticut, but to many others.

A SERIES of illustrated articles on "Radiography," by Mr. James Quick, is begun in the October number of *Science Gossip*. The same issue also contains the continuation of articles on "British Freshwater Mites" and "Butterflies of the Palæarctic Region," and numerous other contributions of popular science.

THE Royal Technical Institute, Salford, has issued its calendar for the session 1899–1900. The list of classes is a large one, and, judging from the illustrations of laboratories, workshops, &c., given, the institute is equipped in a very efficient manner.

THE additions to the Zoological Society's Gardens during the past week include a Smooth-headed Capuchin (*Cebus monachus*) from South-east Brazil, presented by Mr. M. P. Peeker; a Chopi Starling (*Aphobus chopi*) from Brazil, presented by Mr. W. R. Routledge; two Orange-flanked Parrakeets (*Brotogerys pyrrhopterus*) from Western Ecuador, presented by Mr. W. H. St. Quintin; three Palm Squirrels (*Sciurus palmarum*) from India, presented by Mrs. M. E. Tracy; a Brown Capuchin (*Cebus fatuellus*) from Guiana, a Guinea Baboon (*Cynocephalus sphinx*) from Africa, a Striped Snake (*Tropidonotus ordinatus sirtalis*) from North America, three Common Snakes (*Tropidonotus natrix*), a Four-lined Snake (*Coluber quatuorlineatus*), a Tessellated Snake (*Tropidonotus tessellatus*), a Smooth Snake (*Coronella austriaca*), a Glass Snake (*Ophiosaurus apus*), an Eyed Lizard (*Lacerta ocellata*), six Slowworms (*Anguis fragilis*), European, deposited; two Baillon's Aracaris (*Andigena bailloni*) from Brazil, a White-browed Amazon (*Chrysotis albifrons*) from Honduras, twelve Dwarf Chameleons (*Chamaeleon pumilus*) from South Africa, purchased; a Wapiti Deer (*Cervus canadensis*), an Axis Deer (*Cervus axis*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

COMET GIACOBINI (1899 E).—We have received the following elements and ephemeris (calculated by Herr J. Moller) from the Centralstelle at Kiel.

Elements.

T = 1899 Aug. 26·707. Berlin Mean Time.

$$\left.\begin{aligned} \omega &= 358^\circ\ 46'\cdot1 \\ \Omega &= 273\ \ 26\cdot9 \\ i &= 79\ \ 53\cdot5 \end{aligned}\right\} 1899\cdot0$$

$$\log q = 0\cdot23796$$

Ephemeris for 12h. Berlin Mean Time.

1899.	R.A. h. m. s.	Decl. ° ′	Br.
Oct. 5	16 36 59	−3 18·7	0·93
7	39 50	2 41·4	
9	42 42	2 5·1	0·86
11	45 34	1 29·5	
13	48 27	0 54·6	0·81
15	51 20	−0 20·3	
17	54 14	+0 13·3	0·76
19	16 57 8	+0 46·4	

HOLMES' COMET (1899 *d*).—M. H. J. Zwiers gives in *Ast. Nach.* (Bd. 150, No. 3595) an extended ephemeris of this comet, in the hope that it may still be observed by any one having the necessary optical power, and thus permit of a more exact determination of this orbit.

1899.	R.A. h. m. s.	Decl. ° ′ ″	Br. $(r)^{-2}$	Br. $(r\Delta)^{-2}$
Oct. 12	2 59 45·75	+48 10 16·1		
13	58 53·29	16 57·5		
14	57 58·94	23 18·9		
15	57 2·77	29 19·7	0·1647	0·05900
16	56 4·85	34 59·8		
17	55 5·26	40 18·7		
18	54 4·07	45 16·1		
19	2 53 1·35	+48 49 51·7		

THE ROTATION OF THE SUN.—In a publication issued from the Lund Observatory, Herr C. A. Schultz Steinheil gives the results of his complete discussion of Dunér's spectroscopic determinations of the sun's rotation, extending over the period June 3, 1887–May 18, 1889.

Taking Dunér's spectroscopic values for different positions round the limb and the centre, these are reduced to heliographic coordinates by a table of declination corrections supplied to the author by M. Dunér, and so furnish over 600 equations of condition, which when grouped according to latitude are brought down to 22. Solving these by the method of least squares, the final result appears as

$$\begin{aligned} x &= 2\cdot054 \quad \pm 0\cdot0042 \\ i &= +\ 18^\circ\cdot12 \pm 0\cdot25 \\ \Omega &= +\ 28^\circ\cdot00 \pm 0\cdot50 \end{aligned}$$

This means that the result of the new discussion of Dunér's spectroscopic observations is that the sun rotates so that a point on its equator moves with a uniform velocity of 2·054 kilometres per second round an axis the inclination of which towards the axis of the ecliptic is 18°·12, the longitude of the intersection of the sun's equator with the ecliptic being +28°·00.

The value of the velocity $x = 2\cdot054$ is not the true velocity, but the synodic; we get the true value by adding $2d \sin \omega$, where d is the velocity of the earth in its orbit in kilometres per second, and ω the semi-diameter of the sun, expressed in angular measures as seen from the earth.

THE POLARIS MULTIPLE STAR.—Prof. W. W. Campbell is reported to have stated in the *New York Times*:—

"The recent observations of Polaris at the Lick Observatory show that its velocity is variable. It is *approaching* the solar system now (September 12) with a velocity of 8 kilometres per second. This will increase in two days to 14 kilometres, and in the next two days will decrease to its former value of 8 kilometres. This cycle of changes is repeated every *four* days. . . . The orbit is nearly circular, and is comparable in size with the moon's orbit round the earth.

"This centre of gravity, and therefore the binary system, is approaching the solar system at present with a velocity of 11·5 kilometres per second. A few measures of the velocity of Polaris made here (Lick) in 1896 gave its velocity of approach at the rate of 20 kilometres per second. Part of this change since 1896 could be due to a change in position of the orbit of the binary system, but most of it must have been produced by the attraction of a *third* body on the two bodies comprising the '*four-day*' system."

A CORRESPONDENT to the *Scientific American* (September 16) says that Mr. J. A. Brashear has just completed one of the pair of large astronomical camera doublets for the Observatory of the University of Heidelberg. They are next to the largest so far made, being 16 inches clear aperture and 80 inches focal length. Two of these doublets, each consisting of four lenses, are to be made, and are to be used almost exclusively for the photographic discovery of new asteroids. The reason for using two cameras is to provide a check on the possible inaccuracies inseparable from the use of photographic plates, such as false images, &c. The track of an asteroid with a lens of this focus on an 8 × 10 plate is only about one-twentieth of an inch long for an exposure of three hours. As the curves of the lenses have necessarily to be very deep, the casting of the great discs was found to be very troublesome. The fund for the equipment has been provided by Miss Catherine Bruce, of New York City, who was also the donor of the largest photographic doublet (24-inch aperture), to the Harvard College Observatory at Arequipa.

WE learn from the *Evening Standard* that the expedition sent by the Vienna Academy of Science to India to observe the shower of meteoric Leonids during the night of November 14–15, or the following night, has started from Trieste. The leader of the expedition is Herr Director Weiss, of the Vienna Observatory, who is accompanied by Prof. von Hepperger, of the Gratz University, the astronomers, Dr. Hillebrand, Dr. Prey, Herr Rheder, and Dr. Mache. The Indian Government has promised to give the expedition, which will make its observations near Delhi, every possible assistance.

THE FREEDOM OF THE CITY OF MANCHESTER.

ON Friday, October 6, the City of Manchester conferred her freedom on Enrigueta Augustina Rylands, Robert Dukinfield Darbishire, and Richard Copley Christie.

MRS. RYLANDS.

Mrs. Rylands presented to the city the library, magnificent in its contents and beautiful in its fabric, which she built in memory of her husband, John Rylands, whose name it bears—John Rylands, who as "a Manchester merchant built up from the lowliest beginnings a business of unparalleled magnitude, and left behind him a name for industry that never hasted nor rested, and a probity that knew no shame."

Principal Fairbairn, in his inaugural address, drew a remarkable parallel between Alexandria, whose library was the richest in the world, and Manchester, "cities, whose princes were merchants and whose merchants princes," and, he added, "everything that raises a great provincial and industrial city to metropolitan rank makes for higher order, sweeter life and purer manners." The opening of this great library calls for national jubilation.

The noble fabric, designed by Mr. Basil Champneys, is in the fourteenth century Gothic style, and is possibly the finest building erected in England in this generation. The building is built entirely of Penrith limestone, the exterior being the dark red Barbary stone, and the interior delicately shaded Shawk stone.

The staircase which leads to the main library is surmounted with a beautiful octagonal lantern surrounded by a carved stone gallery. The library proper is set back ten feet from the line of the building in order to secure a sufficient supply of light, and is built on the collegiate plan in a long aisle ending in an apse, the total length being 148 feet.

The building is vaulted and groined throughout in stone, it is divided into eight bays occupied by bookcases, and contains a gallery in which this arrangement is repeated; two large rooms opening from the apse contain the collection of Bibles, and the maps. The whole building is elaborately finished with statues and carving, and the fittings are all in harmony with the general scheme of decoration.

Two beautiful traceried windows, by Mr. Charles Kempe, form a notable addition to the beauties of the building. The library contains the famous Althorp collection, and Mrs. Rylands' private collection, which contains Wycliffe MSS. and Wynkyn de Wordes; the library has been endowed, and will be kept up to date.

MR. R. D. DARBISHIRE AND MR. R. C. CHRISTIE.

When Sir Joseph Whitworth lay on his deathbed he attempted to complete a scheme for the utilisation of his property.

But he could not explain so vast an idea, and, throwing out his hands, exclaimed "I cannot do it now; I must leave it to you, who know what it means!"

And it was to Lady Whitworth, to Mr. Christie and to Mr. Darbishire that he left his great wealth.

Lady Whitworth has followed her husband; Manchester has created the two remaining co-legatees her honorary citizens in recognition of the admirable way they have carried out their trust.

In connection with this trust, the legatees presented the site of the Manchester Technical School, and contributed largely to the School of Art; made many valuable gifts of money to the Owens College for the engineering laboratory, the museum, the college hospital property, and for general purposes; and presented ten acres of valuable land as an athletic ground for the College; finally presented the Whitworth Hall, now in course of erection at a cost of 50,000*l*. Presented and partially endowed the Whitworth Park and Art Gallery; erected a public library and hall at Openshaw (where Sir J. Whitworth and Co.'s works are situated).

In addition to the great personal labours in the wise and generous application of the Whitworth estate, Mr. Christie rendered invaluable service to the College in the times of storm and stress. Mr. Christie occupied in 1854–5 the united Chairs of History, Political Economy, Law and Jurisprudence. He is president of many learned societies, and chairman of numerous public bodies, charities and trusts; he is president of the Cancer Home and Pavilion, an admirable institution which originated in his generosity.

His chief literary production is the masterly biography of Etienne Dolet, the second edition of which has just been published.

The magnificent new library at the Owens College which bears his name was his personal gift, and was erected at a cost of 21,000*l*.

The total sum which passed through the hands of the Whitworth Trustees was 1,250,000*l*.; of that sum, 250,000*l*. was spent in redeeming promises and obligations, and the legatees themselves are responsible for the distribution of 960,000*l*.

W. T. L.

VISIT OF THE INSTITUTION OF ELECTRICAL ENGINEERS TO SWITZERLAND, AUGUST 31 TO SEPTEMBER 8.

CONSERVATIVE principles are no doubt of considerable service to England, but perhaps least so when applied to the problems of industry. It is a curious and possibly significant fact that as an electrical power England occupies a very insignificant position, and this in spite of the circumstance that the foundations of the industry were to a great extent laid by English engineers. Some years ago a very authoritative statement was made that in so far as ships of war are concerned our best policy is to watch the experiments of foreign nations and to profit by them, rather than make experiments for ourselves; and it is not uncommon to hear similar remarks with regard to the industrial use of electrical appliances. Unhappily we seem to have forgotten the immense advantages which have accrued to us from our pioneering of the railway industry. No doubt in the early days many mistakes were made and much money was spent in railway experimenting, which foreign countries were afterwards saved; but meanwhile the railway industry had become established in England, and other countries were for many years practically compelled to purchase their railway equipments in England. It seems to the writer of this article that the position formerly occupied by England in railway matters has been taken by America in respect of electric traction, and by Switzerland in regard to the industry of the distribution of electric power. We now certainly profit by American pioneering in electric lighting and tramway work—but we do not get their experience for nothing, for meanwhile their manufacturing industries have become established, and America takes tithe of us when we become her customers. In Switzerland the absence of coal and the presence of an industrious and highly educated population has no doubt co-operated to bring about the wonderful progress which has been made in developing water powers electrically, and in establishing the corresponding industry of the manufacture of electrical appliances. It was on all accounts a happy inspiration for the Institution of Electrical Engineers to visit Switzerland, and for its members to become personally acquainted with the great electrical works of that country; it is only to be regretted that the remainder of the British public did not accompany the members.

Of course we had long understood that the Swiss had done great things electrically, but a visit was necessary to enable us to form an adequate idea of the industrial revolution which has been effected, and whose importance it is impossible to over-estimate. It is also impossible to overestimate the kindly hospitality which was extended to the Institution by the great Swiss manufacturing firms, and indeed by the whole electrical fraternity of Switzerland. We were received everywhere with open arms, works were not only thrown open to our inspection, but every effort was made to explain everything that required explanation, and we were made to feel that not only were we guests, but welcome guests. The following brief account is not intended to be a technical description of our visit, for which the electrical journals may be consulted (an excellent account has already appeared in *Engineering*), but is rather in the nature of a record of the writer's general impressions.

September 1.—About half the party arrived at Bâle in the morning and spent the afternoon in a visit to the Alioth works at Münchenstein. There is a great similarity between these works and those of Brown, Boveri and Co. at Baden; both are new, both are clean, both are worked for the most part by polyphase motors, both of them make excellently designed machinery, mostly of the alternate current three-phase type, and both of them seemed to have as much work on hand as they could carry out. Though a minor matter, the design of the brush holders for continuous current dynamos at Münchenstein met with some attention; they were very neatly made of aluminium on correct dynamical principles.

September 2.—The rest of the party having arrived we went to see the great Power Station at Rheinfelden on the right hand bank of the Rhine. This station has a capacity of twenty turbines of 840 horse power each, the power being supplied by the water of the Rhine with a fall of from three to five metres. To meet variations in the level of the river, the turbines are constructed in a rather peculiar manner, and in fact consist of two turbines on one shaft. The turbine shafts are supported on an oil film, pumped in below a flange; the same high pressure oil being also employed to work the differential governing gear, which it appeared to do very well indeed. However, the load on the dynamos at Rheinfelden is pretty steady, but we found at some other stations that regulation was performed by hand, especially when the power was used for railway or tramway purposes. Some of the power is used for lighting and motors in the villages round about Rheinfelden, and up to a considerable distance away, the three-phase system being employed at a line pressure of 6800 volts. The bulk of the power, however, is used for chemical works on the spot, viz., aluminium, soda and bleach, and carbide, but we were not allowed to see any of these works. The power is a good deal cheaper than at Niagara, and the whole installation gave one the idea that it had "come to stay," the hydraulic works being very solid and the power house roomy and convenient and well kept, though no doubt it had suffered an extra clean up.

The party was entertained at lunch by the directors of the Rheinfelden works; and Herr Rathenau came from Berlin to welcome us, and give us an invitation to visit Berlin next year, an invitation which it is to be hoped the Institution will accept; in any case, Herr Rathenau deserves our best thanks.

In the afternoon we went on by train to the works of Brown, Boveri and Co. at Baden (Switzerland). The works are fairly large, 1300 men and a staff of 170 being employed, and are as much as possible under one roof. Here we saw much the same kind of work that we had seen at the Alioth works, but on a much larger scale. The most interesting exhibit was undoubtedly Mr. C. E. L. Brown himself, who took great pains to ensure our seeing as much as possible in the time at our disposal. The bulk of the work appears to be the construction of three-phase generators and motors of the ordinary type. The large generators were mounted very conveniently with the fixed portion (armature) on trunnions so that it could be turned round for the convenient execution of repairs. The tools were very modern, but there was not nearly so much repeat work being done as the writer at least had expected: nor was there any show of automatic machines. In fact the works were more like an English than an American works, though on a larger scale and newer than any similar works in England.

September 4.—The party being now at Zürich, expeditions were made to the Zürich central station, the works of the Oerlikon Company, the gas engine power house of the Zürich-Oerlikon-Seebach tramway, and the works of Messrs. Escher, Wyss and Co.

The Central Power Station.—The whole of the water of the river Limmat, which drains the Lake of Zürich, is, or can be, turned through the turbines of the power station, the general construction being very similar to that at Rheinfelden. A good deal of the power is used for pumping water, the excess water being used in high pressure turbines for electric generation.

The Oerlikon works are very like the works at Baden, but are much older, and the generators on the three-phase principle appeared to be chiefly of the inductor type. The design of the three-phase motors appears to depend very much on the size, the small ones having simple short circuited squirrel-cage rotors, while the larger ones have a regular winding, coupled up star fashion, and arranged for the introduction or removal of resistance by pulling or pressing a rod passing up the rotor shaft. We saw a nearly-finished locomotive for the Jungfrau railway, the motors being three-phase and provided with enormous rheostats for varying the speed and absorbing power when the cars run down hill. Who would have thought twenty years ago that the Arago disc contained such potentialities? The steel castings in this works were good throughout.

The works of Escher, Wyss and Co. do not demand any special note in so far as arrangement, &c., is concerned; but the firm seems thoroughly to understand the art of turbine making, as it should do, seeing that most of the turbines in the country appear to have been made at their works. Special pains were taken here to show us everything that was to be seen, and we had an unrivalled opportunity of inspecting the details of turbine construction.

Dowson Gas Central Station of the Zürich Oerlikon Street Railway at Oerlikon.—It was rather a surprise to us to find the street railway driven by Dowson Gas in a land reputed to be covered with water powers. The writer must admit to feeling a certain amount of satisfaction at the idea that the water powers were getting exhausted in the neighbourhood of Zürich before British Industry had become a thing of the past. The truth is that there will be no more cheap power for Zürich until some one or other of the numerous schemes for converting valleys into lakes is actually accomplished and very likely not even then. With regard to the Dowson plant itself, there was nothing very striking about it. The engines were not particularly large, but they appeared well made and particularly well water-jacketed. Little or no information could be obtained of interest to Gas Engine people; but economy of coal must be a great consideration when it costs 32 francs per 1000 kilos.

At the Selnau Transformer Station we had an opportunity of seeing how high-tension three-phase currents are used for transmitting power to a sub-station at which continuous current at 500 volts is generated for driving tramway motors. One of the most interesting things about this sub-station was the switches used for turning on the three-phase current, and so starting the continuous current generators to which the three-phase motors are directly coupled. As is, of course, well known, it is in general necessary that resistance should be inserted in the rotor circuit of a three-phase motor in order to enable it to start under any sort of a load. At the Selnau sub-station the switch board was placed above a kind of stone cellar into which the high pressure leads were conducted, the pressure being 2000 volts. By moving the levers on the switch board the current could be switched on and resistance gradually removed from the star winding in the rotor circuits, so that by the time these had attained their proper speed, all the additional resistance had been cut out. We saw the operation of starting successfully performed.

A number of diagrams had been prepared to illustrate to us the essential characteristics of the apparatus. One of these curves seemed to show that the efficiency of the three-phase motors remained within a very small percentage of the same value, the load increasing from 40 per cent. to its full value, a fact which seems to illustrate the great advantage which may be and is obtained by using these motors on variable loads.

Visit to Schaffhausen and Neuhausen.—One is, of course, always pleased to see Schaffhausen on its own account, but there did not seem any particular electrical reason for visiting it. There is the usual central station, power being taken from the Rhine with a fall of from 4 to 5 metres. A little higher up the river there is another similar but older station, the tail race of which is built under the head race of the lower station. One of the turbines was governed by a device which looked about as simple as the machinery employed in cotton spinning, but it seemed to act all the same, though not better than the simpler devices employed by Escher, Wyss and Co. Some of the electric power is used for driving the machinery of a worsted spinning mill and twine works which were visited by several members of the party. Some of the water of the Rhine is deflected, one might almost say stolen, from above the falls at Neuhausen to work a plant most artistically situated just opposite the castle. There is no question but that the appearance of the falls has suffered by the water so deflected, and it is understood that local vested interest in the appearance of the falls is likely to prove too strong for those who desire to utilise their power.

Part of the afternoon was spent in a visit to the works of Messrs. Sulzer Bros. at Winterthur, so well known to engineers as the birthplace of economical engines. We saw several of the engines whose economic performances have secured the admiration of the engineering world. They are of the compound, tandem type, with modified Corliss valve gear, both cylinders being steam jacketed, and heavily lagged with a non-conducting compound. Outside all is a coating of planished steel, which gives the engine a remarkably fine appearance. It appears that there is some evidence that these engines have on occasion developed one I.H.P. on as little as six kilos of steam.

On Wednesday, September 6, a meeting of the Institution of Electrical Engineers was held in the great hall of the Polytechnikum, to hear a paper by Prof. Amsler on the water power at Schaffhausen. Dr. Amsler was not present himself, his paper being read by the secretary, and afterwards discussed indiscriminately by the English and Swiss engineers present. It is not to be inferred from this that they necessarily understood one another ; in fact, the writer was rather surprised to find that the linguistic powers of Swiss engineers do not appear to be appreciably greater than those of their English *confrères*.

It is usual to see the Polytechnikum of Zürich held up for our admiration as representing all that is best in technical education. If magnificence of building, opulence in apparatus and luxury of appointment constitutes a successful Polytechnik, then there is no doubt that quite apart from its staff the Zurich institution deserves the position which it apparently commands. The writer cannot help saying that he did not see a single piece of apparatus which he had not seen thousands of times before, that nearly all the apparatus in the Physical Laboratory appeared to him to be clumsy and old-fashioned in design, and that he saw no evidence of anything except an immense amount of what may perhaps be suitably described as second-class teaching of the "fife and drum" order. With regard to the Chemical Laboratory, the appliances were magnificent ; but there again, so far as the actual laboratories were concerned, there was not very much of interest, or if there was we did not see it. The basement of the chemical building was taken up by the most magnificent appliances for drawing in fresh air, either through a stream of water in summer time, or over a heated surface in winter, the whole of the air supply of the building being treated in this manner. So far as the writer could judge, the electro technic department appeared to be the most interesting part of the Polytechnikum, and there was no lack of machinery of all kinds of the latest type. It is understood that the Swiss electrical manufactories make great use of the facilities for testing afforded by the electro technic department of the Polytechnikum. It is fair to add that we were rather hurried in our visit ; neither the writer nor any one else saw the whole of the departments ; and it was the middle of vacation time, when the busiest chemical laboratory looks like a desert.

Thursday, September 7, was practically occupied by a cheap trip to Engelberg, except that it was not particularly cheap. The greater number of the members visited the Stansstad-Engelberg Railway, and for the first time the majority were able to see how a railway may be driven by means of three-phase motors. The starting and stopping of these machines apparently goes on in the smoothest way, and when the cars are running downhill the motors work as generators and pump power back to the generating station, where it is absorbed by resistances. A still better illustration of traction on the three-phase system was afforded by the visit on the last day of the meeting to the Kander power station, near Spiess, and then to the Burgdorf-Thun Railway. In fact, there was a tolerable consensus of opinion that this was the most important day of the tour. The Kander station is not large, but is equipped in the most modern manner by Brown, Boveri and Co. The water of the Kander at Spiezwyler, with an effective head of about 69 metres, is carried in an iron pipe down to the turbine house, where it operates turbines of about 900 horse-power working upon three-phase alternate current generators working at 4000 volts "composed" pressure and 40 cycles per second. This current is partially used for distribution in the neighbourhood ; it is partly raised to 16,000 volts, and transmitted to Berne, Burgdorf and Munsingen, where it is re-transformed and used for general purposes. In addition to this, a large part of the power is transmitted at 16,000 volts, and distributed by means of transformer stations along the course of the Burgdorf-Thun Railway at a pressure of 750 volts. Now an electric railway, as everybody knows, takes its power in a very irregular manner, so that the engineers of the Kander station have had to face the difficulty of regulating a load part of which is practically constant and part of which is exceedingly variable. Some, if not all, of the generators are run in parallel, which means that all of them run strictly in synchronism ; consequently, if a load varies, the water-supply must be varied to each turbine at the same time and in the same manner. This was being accomplished by the apparently primitive device of having a man on the stop-valve of each turbine. The writer does not feel that he is entitled to pass an opinion on this practice ; but on mentioning what he had seen to M. R. Thury, of Geneva, who has had immense experience of hydraulic electric stations, that engineer expressed himself as confident that it is quite possible to regulate even such a variable load as that of the Kander automatically. The writer was informed that there was an accident to the water pipes at the Kander station not very long ago which upset the regulating devices. The pressure at which the current is generated was regulated by two men at the switch board, who constantly varied the exciting current of the exciters of the generators, which was itself furnished by an independent dynamo which was the subject of regulation. In a station of this kind the difficulty of regulation is no doubt affected by the fact that any variation in the water supplied to the turbines necessarily alters the pressure under which the water is delivered. The switch board was a fine complicated affair on a base of white marble, and some of the fittings appeared to be from America.

Burgdorf-Thun Railway.—This railway, 40 kilometres long, is not distinguished in any way from an ordinary railway except that it is being worked electrically by power transmitted from the Kander station. The rolling stock consists of ordinary carriages hauled by electric locomotives, each of which carries two asynchronous 300-horse power motors. The motors are connected with the axles through the intermediary of gearing which we were informed can be adjusted to run at either of two speeds, intermediate regulation being obtained by varying the existence of the rotor windings. Immense rheostats are required for motors of this kind, and are carried to a large extent on the top of the locomotive, so that it has a very strange appearance. Two trolley wires are used, the third one being of course the rails, and into this three-wire system current is fed at intervals by fourteen transformer stations. There is nothing of the tramway about this road. It forms part of the permanent railway system of Switzerland, and runs under much the same conditions as if the trains were hauled by steam locomotives.

The average speed is about 18 kilometres per hour with a train of fifty-five tons. Besides the locomotives, automobile carriages equipped up to 240-horse power are provided for the greater part of the passenger traffic, and these trains run at 36 kilometres per hour. Nothing could have been smoother or more satisfactory than the way in which the train (hauled in this case by one locomotive) was stopped and started, and it got up its speed with satisfactory quickness. It may be safely predicted that though this is the first railway of the type (as distinguished from a tramway) it will not be the last, for the transmission of current at 16,000 volts does not demand wires of more than two millimetres diameter for the distances mentioned. No difficulty seems to be experienced in insulation. Ordinary insulators of the double petticoat type without oil are employed, and no special precautions are taken with regard to the posts on which these wires are supported except to inscribe upon them a genial warning as to the fate likely to befall anybody meddling with them.

The railway up the Jungfrau is also a very interesting work, and an excellent day was spent in a visit to it. It goes up to the Rothstock a long way above the Wengern Alp, and there it ends at present in a tunnel. It happened that while some of the party were standing close to the locomotive in the tunnel the line was struck by lightning, the fuses blown in the power station, and the automatic break on the locomotive instantly went into action, though the train was at rest. From the electrical point of view, there was not much to be seen on the Jungfrau Railway, but we had splendid weather, and regarded the trip as a day's holiday.

On the whole we may, perhaps, say that we saw more, but not better, electrical work than can be done in England. We saw that Swiss engineers have the courage of their convictions, and have done more in railway work than most of us had ever dreamed of; and we saw that, as regards the carbide and similar industries, we cannot hope to compete in England till we can get at something cheaper than steam power. On the other hand, English industries in general cannot be regarded as threatened by Swiss enterprise; and Switzerland itself, regarded as a manufacturing country, requires (as Mr. Raworth remarked) to be rolled and to have its lakes filled up.

RICHARD THRELFALL.

THE BRITISH ASSOCIATION.

SECTION K.

BOTANY.

OPENING ADDRESS BY SIR GEORGE KING, K.C.I.E., LL.D., F.R.S., PRESIDENT OF THE SECTION.

A Sketch of the History of Indian Botany.

THE earliest references in literature to Indian plants are, of course, those which occur in the Sanskrit classics. These are, however, for the most part vague and obscure. The interest which these references have, great as it may be, is not scientific, and they may therefore be omitted from consideration on the present occasion. The Portuguese, who were the first Europeans to appear in India as conquerors and settlers, did practically nothing in the way of describing the plants of their Eastern possessions. And the first contribution to the knowledge of the botany of what is now British India was made by the Dutch in the shape of the "Hortus Malabaricus," which was undertaken at the instance of Van Rheede, Governor of the territory of Malabar, which during the latter half of the seventeenth century had become a possession of Holland. This book, which is in twelve folio volumes and is illustrated by 794 plates, was published at Amsterdam between the years 1686 and 1703, under the editorship of the distinguished botanist Commelyn. Van Rheede was himself only a botanical amateur, but he had a great love of plants and most enlightened ideas as to the value of a correct and scientific knowledge of them. The "Hortus Malabaricus" was based on specimens collected by Brahmins, on drawings of many of the species made by Mathæus, a Carmelite missionary at Cochin, and on descriptions originally drawn up in the vernacular language of Malabar, which were afterwards translated into Portuguese by Corneiro, a Portuguese official in Cochin, and from that language finally done into Latin by Van Douet. The whole of these operations were carried on under the general superintendence of Casearius, a missionary at Cochin. Of this most interesting work the plates are the best part; in fact, some of these are so good that there is no difficulty in identifying them with the species which they are intended to represent. The next important contribution to the botanical literature of Tropical Asia deals rather with the plants of Dutch than of British India. It was the work of George Everhard Rumph (a native of Hanover), a physician and merchant, who for some time was Dutch Consul at Amboina. The materials for this book were collected mainly by Rumphius himself, and the Latin descriptions and the drawings (of which there are over one thousand) were his own work. The book was printed in 1690, but it remained unpublished during the author's lifetime. Rumph died at Amboina in 1706, and his manuscript, after lying for thirty years in the hands of the Dutch East India Company, was rescued from oblivion by Prof. John Burman, of Amsterdam (commonly known as the elder Burman), and was published under the title of "Herbarium Amboinense," in seven folio volumes, between the years 1741 and 1755. The illustrations of this work cover over a thousand species, but they are printed on 696 plates. These illustrations are as much inferior to those of Van Rheede's book as the descriptions are superior to those of the latter. The works of Plukenet, published in London between 1696 and 1705, in quarto, contain figures of a number of Indian plants which, although small in size, are generally good portraits, and therefore deserve mention in an enumeration of botanical books connected with British India. An account of the plants of Ceylon, under the name "Thesaurus Zeylanicus," was published in 1737 by John Burman (the elder Burman), and in this work many of the plants which are common to that island and to Peninsular India are described. Burman's book was founded on the collections of Paul Hermann, who spent seven years (from 1670 to 1677) exploring the flora of Ceylon at the expense of the Dutch East India Company. The nomenclature of the five books already mentioned is all uninominal.

Hermann's Cingalese collection fell, however, sixty years after the publication of Burman's account of it, into the hands of Linnæus, and that great systematist published in 1747 an account of such of the species as were adequately represented by specimens, under the title "Flora Zeylanica." This Hermann herbarium, consisting of 600 species, may still be consulted at the British Museum, by the Trustees of which institution it was acquired, along with many of the other treasures possessed by Sir Joseph Banks. Linnæus's "Flora Zeylanica" was followed in 1768 by the "Flora Indica" of Nicholas Burman (the younger Burman)—an inferior production, in which about 1500 species are described. The herbarium on which this "Flora Indica" was founded now forms part of the great Herbarium Delessert at Geneva.

The active study of botany on the binominal system of nomenclature invented by Linnæus was initiated in India itself by Koenig, a pupil of that great reformer and systematist. It will be convenient to divide the subsequent history of botanic science in India into two periods, the first extending from Koenig's arrival in India in 1768, to that of Sir Joseph Hooker's arrival in 1849; and the second from the latter date to the present day.

The pioneer John Gerard Koenig was a native of the Baltic province of Courland. He was a correspondent of Linnæus, whose pupil he had formerly been. Koenig went out to the Danish settlement at Tranquebar (150 miles south of Madras) in 1768, and at once began the study of botany with all the fervour of an enthusiasm which he succeeded in imparting to various correspondents who were then settled near him in Southern India. These friends formed themselves into a society under the name of "The United Brothers," the chief object of their union being the promotion of botanical study. Three of these brothers, viz. Heyne, Klein and Rottler, were missionaries located near Tranquebar. Gradually the circle widened, and before the century closed the enthusiasm for botanic research had spread to the younger Presidency of Bengal, and the number of workers had increased to about twelve, among whom may be mentioned Fleming, Hunter, Anderson, Berry, John, Roxburgh, Buchanan (afterwards Buchanan-Hamilton), and Sir William Jones, so well known as an Oriental scholar. At first it was the custom of this brotherhood merely to exchange specimens, but gradually names began to be given, and specimens, both named and unnamed, began to be sent to botanists of established reputation in Europe. Many plants of Indian origin came thus to be described by Retz, Roth, Schrader, Willdenow, Vahl and

Smith. Rottler was the only member of the band who himself published in Europe descriptions of any of the new species of his own collecting, and these appeared in the "Nova Acta Acad. Nat. Curiosorum" of Berlin. A little later Sonnerat and other botanists of the French settlement at Pondicherry sent large collections of plants to Paris, and these were followed at a considerably later date by the collections of Leschenhault. These French collections were described chiefly by Lamarck and Poiret. Hitherto botanical work in India had been more or less desultory, and it was not until the establishment in 1787 of the Botanic Garden at Calcutta that a recognised centre of botanical activity was established in British India. Robert Kyd, the founder of that Garden, was more of a gardener than a botanist. He was, however, a man of much energy and shrewdness. The East India Company was still in 1787 a trading company, and a large part of their most profitable business was derived from the nutmegs and other spices exported from their settlements in Penang, Malacca, Amboina, Sumatra, and other islands of the Malayan Archipelago. The Company were also in those days the owners of a fine fleet of sailing vessels, and the teak of which these ships were built had to be obtained from sources outside the Company's possessions. The proposal to found a botanic garden near Calcutta was thus recommended to the Governor of the Company's settlements in Bengal on the ground that, by its means, the cultivation of teak and of the Malayan spices might be introduced into a province near one of the Company's chief Indian centres. Kyd, as a Lieutenant-Colonel of the Company's engineers, and as secretary to the Military Board at Calcutta, occupied a position of considerable influence, and his suggestion evidently fell on no unwilling ears; for the Government of Bengal, with the promptitude to accept and to act on good advice in scientific and semi-scientific matters which has characterised them from the day of Kyd until now, lost no time in taking steps to find a site for the proposed garden. Colonel Kyd's official proposal was dated June 1, 1786, and, in a despatch dated August 2, the Calcutta Government recommended Kyd's proposal to the Court of Directors in London. Posts were slow and infrequent in those days, and the Calcutta Government were impatient. They did not wait for a reply from Leadenhall Street, but in the following July they boldly secured the site recommended by Colonel Kyd. This site covered an area of 300 acres, and the whole of it, with the exception of thirty acres which were subsequently given up to Bishop Middleton for an English college, still continues under cultivation as a botanic garden. Kyd died in 1793, and in the same year his place as superintendent of the garden was taken by Dr. William Roxburgh, a young botanical enthusiast, and one of Koenig's "United Brotherhood." Roxburgh had studied botany in Edinburgh, where he was a favourite pupil of Dr. Hope. Desirous of seeing something of foreign countries, he made several voyages to Madras in ships belonging to the Honourable East India Company. In 1776 he accepted an appointment in the Company's medical establishment, and was posted to the town of Madras, where he very soon made the acquaintance of Koenig. Roxburgh was shortly after transferred to a remote district, a good deal to the north of Madras, then named the Northern Circars. The station of Samulcotta, which formed Roxburgh's headquarters during his sojourn in the Circars, stands on the edge of a hilly region possessing a very interesting flora, and this flora he explored with the greatest ardour; and, as part of the result of his labours, an account of some of the most interesting of its plants was published in London, at the East India Company's expense, in three large folio volumes, under the title, "The Plants of the Coast of Coromandel." This was Roxburgh's earliest publication on a large scale. The first part of this book appeared in 1795, and the last not until 1819, *i.e.* five years after the author's death. The increased facilities afforded to Roxburgh after his transfer to a comparatively well-equipped institution like that at Calcutta induced him at once to begin the preparation of descriptions of all the plants indigenous to British India of which he could procure specimens. And so diligently did he work that, when he was finally driven from India by ill-health in 1813, he left complete and ready for publication the manuscripts of his "Flora Indica" and of his "Hortus Bengalensis" (the latter being an enumeration of the plants in cultivation in the Calcutta garden). He also left admirable coloured drawings (mostly of natural size) of 2533 species of plants indigenous to India. Seldom have twenty years yielded so rich a botanical harvest! Dr. Roxburgh was thus the first botanist who attempted to draw up a systematic account of the plants of India, and his book, which is on the Linnæan system, is the basis of all subsequent works on Indian botany; and until the publication of Sir Joseph Hooker's monumental "Flora of British India," it remained the only single book through which a knowledge of Indian plants could be acquired. Roxburgh was immediately succeeded in the Calcutta garden by Dr. Buchanan-Hamilton, a man of many accomplishments, who had travelled from Nepal in the North to Ava and Mysore in the South, accumulating materials for a gazetteer of the Honourable Company's possessions. Dr. Buchanan was a zoologist as well as a botanist. He had published a valuable account of Mysore, Canara and Malabar, and had collected materials for a work on the Fishes of India, besides having accumulated a large herbarium, part of which may now be consulted at the University of Edinburgh. Prior to his death Buchanan-Hamilton had begun to write a learned commentary on Van Rheede's "Hortus Malabaricus." Many of his Nepalese collections were described in 1825 (a few years before his own death) by Don in his "Prodromus Floræ Nepalensis." Buchanan-Hamilton remained only one year at Calcutta, and in 1815 he was succeeded by Nathaniel Wallich, a native of Copenhagen, who, prior to his appointment to the Calcutta garden, had been attached to the Danish settlement at Serampore, twenty miles higher up the Hooghly. Wallich remained superintendent of the Calcutta garden for thirty years. In 1846 he went to England, and in 1854 he died. During his tenure of office in the Calcutta garden, Wallich organised collecting expeditions to the then little-known regions of Kamaon and Nepal (in the Himalaya), to Oudh, Rohilcund, Sylhet, Tenasserim, Penang, and Singapore. He undertook, in fact, a botanical survey of a large part of the Company's possessions in India. The vast materials thus collected under his own immediate direction, and the various contributions made by others, were taken to London by him in 1828. With these were subsequently incorporated the collections of Russell, Klein, Heyne, Rottler, Buchanan-Hamilton, Roxburgh, and Wight. And by the help of a band of distinguished European botanists, among whom may be named De Candolle, Kunth, Lindley, Meissner, Nees von Esenbeck, Von Martius and Bentham (the latter in a very special manner), this vast mass of material was classified and named specifically. A catalogue of the collection was prepared by Wallich himself (largely aided by Bentham), and sets of the named specimens were distributed to the leading botanical institutions in Europe, every example of each species bearing the same number. No description of the whole collection was ever attempted, but many of the plants belonging to it were subsequently described in various places and at various times. So extensive was the Wallichian distribution that, amongst the names and synonyms of tropical Asiatic plants, no citation is more frequent in botanical books than that of the contraction "Wall. Cat." Besides the naming and distribution of this gigantic collection, Wallich prepared and published, at the expense of the same liberal and enlightened East India Company, his "Plantæ Asiaticæ Rariores," in three folio volumes with 300 coloured plates. He also contributed to an edition of Roxburgh's "Flora Indica," which was begun by the celebrated Dr. Carey of Serampore, descriptions of many plants of his own collecting. But the task of publishing his discoveries in this way proved beyond his powers, as it would have proved beyond those of any one who had only 365 days to his year, and less than a hundred years as his term of life! Carey and Wallich's edition of Roxburgh's "Flora Indica" was brought to an untimely conclusion at the end of the *Pentandria Monogynia* of Linnæus. Wallich also began an illustrated account of the flora of Nepal under the title, "Tentamen Floræ Nepalensis." But this also came to a premature end with the publication of its second part.

During much of the time that Wallich was labouring in Northern India, Robert Wight, a botanist of remarkable sagacity and of boundless energy, was labouring in Southern India, chiefly in parts of the Peninsula different from those in which Koenig and his band had worked. Wight was never liberally supported by the Government of Madras, and it was mostly by his own efforts and from his own resources that his collections were made and that his botanical works were published. The chief of the latter is his "Icones Plantarum." This book consists of figures with descriptions of more than two thousand Indian species. A good many of the plates are indeed copies from the suite of drawings already referred to as having been made at Calcutta by Dr. Roxburgh. The rest are from drawings made, either by native artists under his personal supervision, or by his own hands. Ample evidence of the extraordinary energy of Dr. Wight is afforded by the facts that, although he had to teach the native artists whom he employed both to draw and to lithograph, the two thousand *Icones* which he published and described were issued during the short period of thirteen years, and that during the whole of this time he performed his official duties as a medical officer.

Besides this *magnum opus*, Wight published his *Spicilegium Nilghirense* in two vols. quarto, with 200 coloured plates. And between 1840 and 1850 he issued in two vols. quarto, with 200 plates, another book named "Illustrations of Indian Botany," the object of which was to give figures and fuller descriptions of some of the chief species described in a systematic book of the highest botanical merit, which he prepared conjointly with Dr. J. Walker-Arnot, Professor of Botany in the University of Glasgow, and which was published under the title "Prodromus Floræ Peninsulæ Indicæ." The "Prodromus" was the first attempt at a flora of any part of India in which the natural system of classification was followed. Owing chiefly to the death of Dr. Walker-Arnot, this work was never completed, and this splendid fragment of a flora of Peninsular India ends with the natural order *Dipsaceae*.

The next great Indian botanist whose labours demand our attention is William Griffith. Born in 1810, sixteen years after Wight, and twenty-four years later than Wallich, Griffith died before either. But the labours even of such devotees to science as were these two are quite eclipsed by those of this most remarkable man. Griffith's botanical career in India was begun in Tenasserim. From thence he made botanical expeditions to the Assam valley, exploring the Mishmi, Khasia and Naga ranges. From the latter he passed by a route never since traversed by a botanist, through the Hookung valley down the Irrawadi to Rangoon. Having been appointed, soon after his arrival in Rangoon, surgeon to the Embassy to Bhotan, he explored part of that country and also part of the neighbouring one of Sikkim. At the conclusion of this exploration he was transferred to the opposite extremity of the Northern frontier, and was posted to the Army of the Indus. After the subjugation of Cabul, he penetrated to Khorassan. Subsequently he visited the portion of the Himalaya of which Simla is now the best-known spot. He then made a run down the Nerbudda valley in Central India, and finally appeared in Malacca as Civil Surgeon of that Settlement. At the latter place he soon died of an abscess of the liver brought on by the hardships he had undergone on his various travels, which were made under conditions most inimical to health, in countries then absolutely unvisited by Europeans. No botanist ever made such extensive explorations, nor himself collected so many species (9000) as Griffith did during the brief thirteen years of his Indian career; none ever made so many field notes or wrote so many descriptions of plants from living specimens. His botanical predecessors and contemporaries were men of ability and devotion. Griffith was a man of genius. He did not confine himself to the study of flowering plants, nor to the study of them from the point of view of their place in any system of classification. He also studied their morphology. The difficult problems in the latter naturally had most attraction for him, and we find him publishing, in the *Linnaean Transactions*, the results of his researches on the ovule in *Santalum*, *Loranthus*, *Viscum*, and *Cycas*. Griffith was also a cryptogamist. He collected, studied, and wrote much on Mosses, Liverworts, *Marsiliaceae*, and Lycopods, and he made hundreds of drawings to illustrate his microscopic observations. Wherever he travelled he made sketches of the most striking features in the scenery. His habit of making notes was inveterate; and his itinerary diaries are full of information, not only on the botany, but also on the zoology, physical geography, geology, meteorology, archæology and agriculture of the countries through which he passed. His manuscripts and drawings, although left in rather a chaotic state, were published after his death under the editorship of Dr. McClelland, at the expense of the enlightened and ever-liberal East India Company. They occupy six volumes in octavo, four in quarto, and one (a "Monograph of Palms") in folio.

Another botanist of much fame, who died prematurely in 1822, after an Indian career of only nine years, was William Jack. In 1814–15, Jack accompanied Ochterlony's army to the Nepal terai. He was transferred in 1818 to the Company's settlement in Sumatra under Sir Stamford Raffles, and during the four years of his residence in Sumatra he contributed to botanical literature descriptions of many new genera and species which were published in his "Malayan Miscellanies." His collections, unfortunately, were for the most part lost by an accident, but those which were saved are now in the Herbarium Delessert in Geneva.

Somewhat similar to Griffith in temperament and versatility was the brilliant Victor Jacquemont, a French botanist who, at the instance of the Paris Natural History Museum, travelled in India for three years from 1829 to 1832. During this period Jacquemont collected largely in the Gangetic plain. He then entered the North-west Himalaya at Mussourie, explored Gharwal and Sirmur, ascended the Sutlej to Kanawer and Piti (at that time unexplored), visited Cashmir, and returning to the plains, crossed Northern Rajputana to Malwa and the Deccan. He finally reached Bombay with the intention of returning to France. But at Bombay he succumbed to disease of the liver, brought on by hard work and exposure. His remains, after having lain in the cemetery there for fifty years, were, with that tender regard for the personality of her famous sons which France has always shown, exhumed in 1881, and conveyed in a French frigate to find a permanent resting-place in the place of Jacquemont's birth. Jacquemont's collections were transmitted to Paris, and his plants were described by Cambessedes and Decaisne, while his non-botanical collections were elaborated by workers in the branches of science to which they respectively appertained, the whole being published in four volumes quarto, at the expense of the French Government.

The roll of eminent botanists who worked in India during the first half of the century closes with the name of Thomas Thomson, who collected plants extensively between 1842 and 1847 in Rohilkund and the Punjab, and again still more extensively during a Government mission to the North-west Himalaya and Tibet which was continued from 1847 to 1849. During this period Dr. Thomson explored Simla, Kanawar, Piti, Cashmir, Ladak, and part of the Karakoram. His collections, which were large and important, were transmitted to the Botanic Garden at Calcutta, and thence in part to Kew. They formed no insignificant part of the materials on which the "Flora Indica" and "Flora of British India" were founded. Dr. Thomson also published an account of his travels—an admirable book, though now jostled out of memory by the quantities of subsequently issued books of Himalayan travel and adventure.

About the year 1820 a second centre of botanical enterprise was established at Seharunpore, in the North-west Provinces. A large old garden near that important town, which had been originally founded by some Mahommedan nobles of the Delhi Court, was taken over by the Honourable Company, and was gradually put upon a scientific basis by Dr. George Govan, who was appointed its first superintendent. Dr. Govan was in 1823 succeeded by Dr. J. Forbes Royle, and he in 1832 by Dr. Hugh Falconer. Dr. Royle made collections in the Jumno-Gangetic plain, in the Lower Gharwal Himalaya, and in Cashmir. He was distinguished in the field of economic rather than in that of systematic botany, his chief contribution to the latter having been a folio volume entitled "Illustrations of the Botany of the Himalaya Mountains." His valuable labours as an economic botanist will be noticed later on. Hugh Falconer was an accomplished palæontologist who devoted but little of his splendid talents to botany. His great contribution to palæontology, the value of which it is almost impossible to over-estimate, consisted of his exploration and classification of the tertiary fossils of the Sewalik range. Falconer was transferred to the Calcutta Garden in 1842. He was succeeded at Seharunpore by Dr. W. Jameson, who explored the botany of Gharwal, Kamaon and Cashmir, but who published nothing botanical, his chief energies having been devoted to the useful work of introducing the cultivation of the China tea plant into British India, and this he did (as will afterwards be mentioned) with triumphant success.

During the first half of the century a considerable amount of excellent botanic work was done in Western India by Graham, Law, Nimmo, Gibson, Stocks and Dalzell, the results of whose labours culminated in the preparation by Graham of a list of the plants of Bombay, which was not, however, published until 1839 (after his death); in the publication by Stocks of various papers on the botany of Scinde; and in the publication by Dalzell in 1861 of his "Flora of Bombay." It is impossible in a brief review like the present to mention the names of all the workers who, in various parts of the gradually extending Indian Empire, added to our knowledge of its botanical wealth. It must suffice to mention the names of a few of the chief, such as Hardwicke, Madden, Munro, Edgeworth, Lance and Vicary, who collected and observed in Northern India, and who all, except the two last mentioned, also published botanical papers and pamphlets of more or less importance; Jenkins, Masters, Mack, Simons and Oldham, who all collected extensively in Assam; Hofmeister, who accompanied Prince Waldemar of Prussia, and whose collections form the basis of the fine work by Klotsch and Garcke (*Reis. Pr. Wald.*); Norris, Prince, Lobb and Cuming, whose labours were in Penang and Malacca; and last, but not least, Strachey and Winterbottom, whose large and valuable collections, amounting to about 2000 species, were made during 1848 to 1850 in the higher ranges of the Kamaon and Gharwal Himalaya, and in the adjacent parts of Tibet. In referring to the latter classic Herbarium, Sir Joseph Hooker remarks that it is "the most valuable for its size that has ever been distributed from India." General Strachey is the only one who survives of the splendid band of collectors whom I have mentioned. I cannot conclude this brief account of the botanical labours of our first period without mentioning one more book, and that is the "Hortus Calcuttensis" of Voigt. Under the form of a list, this excellent work, published in 1845, contains a great deal of information about the plants growing near Calcutta, either wild or in fields and gardens. It is strong in vernacular names and vegetable economics.

(*To be continued.*)

MATHEMATICS AT THE BRITISH ASSOCIATION.

THE visit of the French Association to Dover necessitated some departures from the usual programme of the British Association week, and the mathematical meeting was held this year on Monday, September 18. Prof. Forsyth, of Cambridge, presided over a well-filled room.

The session opened with the formal communication of two reports of committees: the first, drawn up by Prof. Karl Pearson, and practically forming a continuation of a previous report, contains a set of tables of certain functions connected with the integral

$$G(r, \nu) = \int_0^\pi \sin^r\theta e^{\nu\theta} d\theta,$$

for integral values of r from 1 to 50, and for values of ν at certain intervals from 0 to 1. These functions are of importance in certain statistical problems.

The second report consists substantially of the new "Canon Arithmeticus" which Lieut.-Colonel Cunningham has prepared; the Association has made a grant for publishing the tables as a separate volume (they cannot well be fitted into the comparatively small page of the B.A. Report), and it is to be hoped that before long they will become generally available for workers in the Theory of Numbers.

The first of the papers was read by Dr. Francis Galton, on "The Median Estimate." Dr. Galton proposes to substitute a scientific method for the very unsatisfactory ways in which the collective opinion of committees and assemblies of various kinds is ascertained, in respect to the most suitable amount of money to be granted for any particular purpose. How is that medium amount to be ascertained which is the fairest compromise between many different opinions? An average value—*i.e.* the arithmetic mean of the different estimates—may greatly mislead, because a single voter is able to produce an effect far beyond his due share by writing down an unreasonably large or unreasonably small sum. Again, few persons know what they want with sufficient clearness to enable them to express it in numerical terms, from which alone an average may be derived; much deeper thought-searching is needed to enable a man to make such a precise affirmation as that "in my opinion the bonus to be given should be 80*l.*," than to enable him to say "I do not think he deserves so much as 100*l.*, certainly not more than 100*l.*"

Dr. Galton's plan for discovering the medium of the various sums desired by the several voters is to specify any two reasonable amounts A and B, and to find what percentage a of voters think that the sum ought to be less than A, and what percentage b vote for less than B. It may now be assumed that the estimates will be distributed on either side of their (unknown) *median* m, with an (unknown) quartile q, in approximate accordance with the normal law of frequency of error; and thus (using the table of centiles given in the author's "Natural Inheritance") the required median value can be found.

This was followed by a paper "On a system of invariants for parallel configurations in space," by Prof. Forsyth. The process followed by the author is one in which English mathematicians have always excelled—namely, the deduction of difficult analytical results from simple geometrical considerations. Prof. Forsyth's final formulæ may be regarded as invariantive relations between certain definite integrals; the way in which he finds them is as follows:—

Consider any plane curve; if we suppose a circle of constant size to roll on the curve, its envelope will be another curve, which is said to be *parallel* to the original one. If now L be the length and A the area of a curve, it is found that the quantity $A - \frac{1}{4\pi}L^2$ has the same value for the parallel as for the original curve; in other words,

$$A - \frac{1}{4\pi}L^2$$

is *invariantive* for parallel curves. Similarly in space of three dimensions, the envelope of a sphere of fixed size which rolls on a given surface is another *parallel* surface; and if V be the volume contained by a surface, S its superficial area, and L twice the surface-aggregate of the mean of the curvatures at any point, then it is found that the quantities

$$S - \frac{1}{16\pi}L^2 \text{ and } V - \frac{1}{8\pi}LS + \frac{1}{192\pi^2}L^3$$

are invariantive for all parallel surfaces.

Similar results hold for space of n dimensions. At the end of the paper the expressions obtained are shown to be connected with the ordinary invariant-theory of binary forms.

The next paper, read by Prof. Everett, was concerned with "The Notation of the Calculus of Differences." In conjunction with the ordinary symbol Δ, defined by

$$\Delta y_n = y_{n+1} - y_n,$$

Prof. Everett employs another symbol δ, defined by

$$\delta y_n = y_n - y_{n-1},$$

so that

$$\delta = \Delta/_{1+}\Delta.$$

The use of δ simplifies some of the well-known formulæ of the calculus of finite differences.

Prof. A. C. Dixon, of Galway, followed, with a paper "On the Partial Differential Equation of the Second Order." Let z be the dependent, and x and y the independent, variables; and with the usual notation, let

$$p = \frac{\partial z}{\partial x}, \quad q = \frac{\partial z}{\partial y}, \quad r = \frac{\partial z^2}{\partial x^2}, \quad s = \frac{\partial z^2}{\partial x \partial y}, \quad t = \frac{\partial z^2}{\partial y^2},$$

and consider the differential equation

$$f(x, y, z, p, q, r, s, t) = 0.$$

This may be supposed solved by using two more relations

$$u = a, \quad v = b,$$

among the quantities x, y, z, p, q, r, s, t, to give values of r, s, t, which, when substituted in

$$dz = pdx + qdy, \quad dp = rdx + sdy, \quad dq = sdx + tdy,$$

render these three equations integıable. This will not be possible, of course, unless the expressions u, v, fulfil certain conditions. Prof. Dixon considers the case in which u can be so determined that v is only subjected to one condition, and finds that then du is a linear combination of the differential expressions used in Hamburger's method of solution. If such a function u can be found, the system $f=0$, $u=a$, will have a series of solutions depending on an arbitrary function of one variable, and involving two further arbitrary constants.

The next paper, "On the Fundamental Differential Equations of Geometry," was read by Dr. Irving Stringham, of the University of California. Dr. Stringham derives the analytical formulæ for non-Euclidian Geometry by following a procedure indicated by Feye St. Marie, and later discussed in Killing's "Nicht-Euclidischen Raumformen." Within an infinitesimal domain in non-Euclidian space, the propositions of Euclidian

Geometry may be regarded as true; from this fact can be deduced a group of equations typified by

$$\frac{da}{d\alpha}=\frac{f(b)}{\sin\gamma},\ \frac{db}{d\alpha}=\cos\gamma,\ f'(b)=-\frac{d\gamma}{d\alpha},$$

where a, b, c, are the sides of a triangle, and α, β, γ, the corresponding angles. From these, by appropriate eliminations and transformations, the differential equation

$$\{f(a)\}^2=-\kappa^2[1-\{f'(a)\}^2]$$

can be found for the function f. Solving this, we have

$$f(a)=\kappa\sinh\frac{a}{\kappa},$$

and thence can derive the fundamental equations of non-Euclidian measurement.

$$\sinh\frac{a}{\kappa}\Big/\sinh\alpha=\sinh\frac{b}{\kappa}\Big/\sin\beta=\sinh\frac{c}{\kappa}\Big/\sin\gamma.$$

This was followed by the communication of a Report on the Problem of Three Bodies, which Mr. E. T. Whittaker was commissioned to prepare at the Toronto meeting. In a general sketch of the results, Mr. Whittaker explained the transformation which has taken place in dynamical astronomy as a result of the researches of Newcomb, Hill, Lindstedt and Poincaré. Formerly the subject might be said to consist of two departments—the planetary and lunar theories; now the distinction between these was becoming less prominent, as the Problem of Three Bodies was treated in greater generality. Among the advances referred to were Dr. Hill's introduction of periodic orbits as a substitute for Keplerian ellipses in the first approximation to the solution, Newcomb's proof that the problem can be solved by series in which the time occurs only in the arguments of trigonometric functions, Poincaré's theorem that these series are only asymptotic expansions, and Bruns' result that the system possesses no algebraic integrals other than those already known.

A second paper by Prof. Forsyth, "On Singular Solutions of Ordinary Differential Equations," described some properties of the p-discriminant and c-discriminant of an ordinary differential equation of the first order. The two last papers on the list were "An Application and Interpretation of Infinitesimal Transformations," by Dr. E. O. Lovett, of Princeton University, N.J.; and "On Fermat's Numbers," by Lieut.-Colonel Cunningham. In the absence of their authors the papers were communicated by title, and the session was closed.

Looking at the papers as a whole, they were of just that character which makes the B.A. meeting useful to mathematicians; that is, they related not so much to abstruse continuations of well-known theories as to new and little-known subjects, suggestions of improved notations, reports on the recent progress of different branches of mathematics, and generally all those topics for which discussion at a real meeting is more important than the publication of a paper.

PHYSICS AT THE BRITISH ASSOCIATION.

THE attendance of physicists at Dover was rather smaller than usual, on account of the occurrence of the Volta Centenary celebrations at Como and the simultaneous meetings of the French Association for the Advancement of Science at Boulogne. Several of those who in past years have been leaders in the discussions of Section A were this year conspicuous by their absence. Nevertheless, the papers read maintained a high standard of excellence, and the reports presented indicate that good work is being done by the committees appointed for scientific research.

The address delivered by Prof. Poynting, as President of the Section, was the subject of many conversations, not only among physicists but with biologists also; the existence of the sharp line which he indicated between the psychical and physical methods and the phenomena to which each is applicable, was acknowledged on all sides. The physicists were divided on the question of the danger of too much hypothesis, and especially on the possibility of the propagation of electromagnetic waves in air being due to the air as much as to the ether. All, however, were agreed in the expression of thanks to the President, proposed by Sir George Stokes and seconded by Sir Norman Lockyer.

In a paper on the spectroscopic examination of contrast phenomena, Mr. G. J. Burch described experiments which lend great support to the Young-Helmholtz theory of colour-vision. If the eye is fatigued by exposure to a very intense red light, such as sunlight filtered through red screens and focussed on the eye, and a spectrum be then looked at, the red is invisible; but the rest of the spectrum, green to violet, appears in its ordinary colours. Red-blindness is therefore not accompanied by green-blindness, as Hering's theory requires. Further experiments on the blue and violet portions of the spectrum have led Mr. Burch to the conclusion that we have separate primary sensations for blue and violet, in addition to those for red and green, making four altogether instead of the three postulated by the Young-Helmholtz theory. The experiments are the more convincing because carried out with spectral colours, thus avoiding all errors due to the impurity of pigment colours. In the discussion on the paper several members took part; Sir George Stokes said experiments led him to believe that lobelia blue is a primary sensation, and Principal Glazebrook suggested that the theory should be tested by colour-matches on a spectrophotometer.

Prof. Callendar gave the preliminary results of a research on the variation of the specific heat of water with temperature, which he commenced in Montreal with Mr. H. T. Barnes, and which is now being continued by the latter. The method of experiment consists in allowing water to flow steadily through a narrow tube along which a platinum wire runs axially; on passing a constant electric current through the wire the water finally acquires a steady temperature-difference between the inlet and outlet of the tube, which is measured by platinum thermometers and automatically recorded. Radiation corrections are reduced to a minimum by surrounding the tube with a vacuum-jacket, and the electrical energy supplied is measured by observing the current and the potential-difference between the ends of the wire in the tube. The results show that the specific heat of water has a minimum value of 0·995 in the neighbourhood of 40° C., it rises to 1·000 as the temperature falls to 10° C., and continues to rise rapidly as the temperature decreases. On increasing the temperature above 40° C. the specific heat rises to 0·997 at 60° C. Further experiments will be made in the neighbourhood of the freezing point and on either side of it.

The committee on electrolysis and electro-chemistry has undertaken the comparison of the variation of electrical conductivity with concentration, and the variation of freezing point with concentration for identical very dilute aqueous solutions of electrolytes. The electrical measurements have been successfully carried out by Mr. W. C. Whetham, but the freezing point determinations, undertaken by Mr. E. H. Griffiths, have been delayed by the discovery of errors arising from the presence of dissolved gases in the solutions. Incidentally Mr. Griffiths remarked that he was able to measure temperatures to within three or four parts in a million.

Dr. R. A. Lehfeldt, at a subsequent meeting, called attention to a flaw in Nernst's theory of electrolytic solution pressure. According to this theory, when a metal is immersed in an electrolyte ions are torn either from the metal or from the solution according as the solution-pressure is greater or less than the osmotic pressure of the ions in solution. It is usually supposed that the mass of the ions deposited or dissolved is so extremely small that it cannot be detected; the author showed, however, by considering the electrostatic tension due to the ionic charges, that the amount dissolved should be easily weighable, at any rate in the case of zinc.

The stability of an ether containing long, thin, empty vortex filaments was discussed in a communication by Prof. Fitz-Gerald on the energy per cubic centimetre in a turbulent liquid transmitting laminar waves. Lord Kelvin considered this subject in 1887, and concluded that rapid diffusion would make the structure unstable. The author held the opinion (though possibly Lord Kelvin would differ from him) that the turbulency of a sufficiently fine-grained irregularly turbulent liquid would ultimately diffuse so slowly that Lord Kelvin's investigation could be applied to it.

Until the meeting of the Association in 1893, it was generally supposed that the absence of an atmosphere from the moon, and of hydrogen from our own atmosphere, is due to the high average velocity of the gaseous molecules, which is sufficient to carry them beyond the range of the moon's or earth's attraction. On that occasion Prof. Bryan demonstrated the incorrectness of this view for the case of the moon, and he has since extended his calculations to the cases of hydrogen and helium in the earth's atmosphere, and of water vapour in the atmosphere of Mars. The method of calculation is to determine the number of years which would be required for the planet to lose from its surface a layer of the gas one centimetre thick at various temperatures. The results show that the earth might retain helium, but would lose hydrogen appreciably at ordinary temperatures, and that Mars might retain water vapour at ordinary temperatures. If helium ever existed on the earth's surface, it must have escaped when the surface was much hotter than at present, whereas a smaller elevation of temperature would cause water vapour to escape from the surface of Mars.

Prof. W. F. Barrett described the thermo-electric properties of an alloy containing iron 68·8 per cent., nickel 25·0, manganese 5·0, and carbon 1·2. When a thermo-electric couple is formed of this metal and iron, the electromotive force rises with temperature to 300° C.; it then remains steady until 500° C. is reached, after which it falls slightly and rises again to 1100° C.; the fluctuations of electromotive force do not exceed 4 per cent. of the total value. When the alloy forms a couple with nickel the results are similar, but the range of variation is slightly greater.

The committee on the heat of combination of metals in the formation of alloys, appointed last year to assist Dr. A. Galt in his experiments on this subject, reported the completion of their work. Only alloys of zinc and copper have been examined, twenty-two in number and containing from 5 to 90 per cent. of copper; the difference between the amounts of heat evolved by dissolving in nitric acid unit mass of the alloy and corresponding amounts of the mixed metals was taken as the heat of combination of the metals. The results indicate a negative heat of combination for alloys rich in zinc, the numerical value of which is a maximum when the alloy contains 16 per cent. of copper. The formation of an alloy containing about 24 per cent. of copper takes places without absorption or evolution of heat, while for 38 per cent. of copper the heat of combination is a maximum and positive; beyond this it diminishes to zero for pure copper. In the absence of Dr. Galt and other members of the committee no reply was given to a serious criticism by Prof. Vernon Harcourt, that in the experiments no account was apparently taken of the fact that the products arising from the solution of an alloy in nitric acid are not the same as would be obtained from the mixed metals. In his paper read last year at Bristol, Dr. Galt mentioned that he had made many preliminary experiments, and possibly he has examined this point; if not, the results obtained by the committee will be somewhat vitiated.

A preliminary report of the committee on radiation from a source of light in a magnetic field was communicated to the Section, the chief points in which were (1) the discovery that light passing through a magnetic field at right angles to the lines of force suffers absorption (see NATURE, vol. lix. pp. 228–9, January 5, 1899); (2) the various modified forms of triplet are true magnetic perturbations of the same kind as the normal triplet; (3) the spectral lines of a substance may be divided into groups such that all members of one group suffer the same kind of perturbation (see NATURE, vol. lix. p. 248, January 12, 1899).

The Zeeman effect is attributed to the action of a magnetic field on the moving ions; recently Mr. C. E. S. Phillips has discovered an apparently cognate phenomenon, which he described in his paper on the production in rarefied gases of luminous rings in rotation about lines of magnetic force. An electric discharge is passed between soft iron electrodes in a Crookes' vacuum tube; on stopping the discharge and setting up a magnetic field between the electrodes, a luminous ring forms with its plane at right angles to the lines of force and in rotation about the magnetic axis. The direction of rotation is that which would be communicated to negatively charged particles, and is reversed on reversing the magnetic field; the luminosity persists sometimes for a minute, and reversal of the magnetic field causes it to brighten momentarily. Two explanations of the phenomenon have been given; one is that the rotating matter consists of ions or electrons, and the other that the matter consists of gas particles which have acquired a negative charge by contact with the walls of the tube. From experiments of Prof. J. J. Thomson, it appears that negative ions move more quickly than positive, which would account for the greater luminosity of the negative ions when set in rotation.

In a note on deep-sea waves, Mr. V. Cornish endeavoured to trace relations between the amplitude, wave-length, and wind-velocity for waves on the surface of deep water. Sir George Stokes pointed out that the amplitude observed is not that of a simple wave, but is the resultant effect of a train of waves of different periods and lengths.

At the meeting of the Section on Saturday the visitors from the French Association at Boulogne were present, and the President extended to them a hearty welcome, which was acknowledged by M. Benoit, as president of the Physical Section of the French Association. A paper was then communicated by Prof. J. J. Thomson, on the existence of masses smaller than the atoms. He stated that several lines of research lead to a determination of the ratio of the mass of an atom (m) to the charge carried by the atom (e). Among these are electrolysis, the velocity of charged particles in a magnetic field, and the magnetic deflexion of kathode rays. The two latter methods are comparatively simple, because they depend on the observation of luminous effects, but although they agree with each other fairly well, they furnish a value of m/e which is about 1/1000 of that calculated from electrolytic phenomena. It becomes, therefore, a matter for inquiry whether in the former experiments the atom carries a charge greater than that required by Faraday's laws, or whether the charge is carried by a portion only of the atom—in other words, whether a small fraction of the mass of the atom is detachable which has associated with it a negative charge. The simplest crucial experiment is obtained by determining separately either m or e, and the author has devised a means of measuring the latter quantity. He takes a negatively charged metal plate supported horizontally; below this and parallel to it is a very large perforated metal plate, the whole being in rarefied gas at a pressure of about 1/100 mm. mercury. When ultra-violet radiation is directed through the perforated plate to strike the upper plate the latter is discharged, the discharging particles moving along straight lines normal to the two plates. If a magnetic field be now excited with its lines of force parallel to the plates, the particles describe curved paths which are in fact portions of cycloids. When the plates are near together the particles which leave the upper one strike the lower one; if, however, the plates are separated further, the vertex of the cycloidal path comes between them, and the particles do not reach the lower plate, so that the discharge ceases. In the actual experiment there is a gradual, but not abrupt, change in the rate of discharge, possibly because all the particles do not start from the surface of the upper plate. From observations on the distance apart of the plates when the change in the rate of discharge commences, the form of the cycloidal path is determined, and the results show that the smaller value of m/e is applicable to this case and to that of illumination by kathode rays. Further, the amount of electricity discharged by the illuminated plate per second is proportional to the number of particles between the plates, to the charge carried by each (e), and to the velocity of the particles. The last-named quantity is measured by a method due to Prof. Rutherford, so that if the total number of particles in the space is known the value of e can be determined. To count the particles use is made of the fact that they serve as nuclei for the formation of drops out of a condensing vapour, each particle giving rise to one drop. Let a known amount of air of given humidity be suddenly and definitely expanded in the presence of the particles, and observe the rate at which the drops fall; this rate gives the size of the drops, and hence their mass, and since the whole mass of water deposited is known, the number of drops is thus determined. For negative charges the ratio m/e is independent of the nature of the gas, whereas for positive charges its value varies from one gas to another, and corresponds generally with the values given by electrolytic phenomena. Prof. Thomson considers that electrification consists in the removal from the "atom" of a small corpuscle with which the negative charge is associated; the remaining large portion of the mass is positively charged. This view is supported by Prout's hypothesis that the mass of an atom is not invariable, and by the evidence derived by Lockyer and others from spectroscopic observations.

In the discussion which followed upon Prof. Thomson's paper, M. Broca described spectroscopic observations of a spark obtained between two platinum electrodes ½ mm. apart in a Crookes' vacuum tube; the spectra of the regions near the electrodes and the space between them were not alike. Prof. Rücker drew attention to Schuster's experiments, in which the spectrum of a substance not present in the material examined sprung into being in the arc itself. He believed matter to be a complicated collection of units themselves similar. Sir Norman Lockyer said that if we accept the view that elements of smallest atomic weights should appear first in the spectrum of a hot star, we must assume the existence of forms of calcium, magnesium, iron and copper having atomic weights which are submultiples of those assigned to them in ordinary chemistry. Further, the division of the spectra of certain elements into series of lines by Rydberg, Runge and Paschen, and others indicates that the atoms of these elements are complexes; we have, therefore, no reason to suppose that the so-called "atoms" are not dissociable at high temperatures. Prof. Oliver Lodge thought the investigations of Prof. Thomson might turn out to be the discovery of an electric inertia, and lead to a theory of mass. Several speakers expressed their pleasure in receiving the members of the French Association.

In the very short time remaining after the discussion on the previous paper, Prof. Oliver Lodge gave a short account of the controversy respecting the seat of Volta's contact force.

On Monday the Section was subdivided for papers on mathematics and meteorology respectively. In the latter department, over which Sir George Stokes presided, a formal report was presented by the committee on solar radiation. Dr. van Rijckevorsel read a paper in which he traced an intimate connection between the activity of sun-spots and the temperature. The committee on seismology presented a voluminous report on their work, from which it appears that twenty-three stations are now equipped with recording seismographs, and registers have been received from ten of these. Notes on these registers occupy a considerable portion of the report; the rest of the report is abstracted from articles which have already appeared in NATURE (February 16 and March 1, 1899). Mr. T. F. Claxton communicated the preliminary results of a year's work with the seismograph at Mauritius. The diurnal waves are of greater amplitude than at any other observing station, and there is a well-marked bi-diurnal effect possibly connected with barometric pressure. Rapid and large changes of the vertical have occurred on several occasions, in addition to a constant gradual change. Air tremors have given trouble at night. The earthquake effects have been of disappointingly small amplitude, and it is suggested that the ocean may act as a damper to earthquake shocks.

Mr. A. L. Rotch gave an interesting account of the progress achieved during the past year at Blue Hill, Massachusetts, in the exploration of the air with kites. The Hargrave kite with curved surfaces has been found more satisfactory than any other form, and the meteorograph records temperature, humidity, height and wind. Temperature is found to decrease at first with elevation, and afterwards to increase again. The heights attained were on the average greater than in previous years. The author mentioned that the United States Government has arranged for daily simultaneous observations at two heights in the case of a number of stations, the kite being used for the high-level observations. The results are not quite satisfactory, because kites could not be sent up on some days; it is suggested that on such occasions a captive balloon be employed. Prof. Thomson hoped that the variation of atmospheric electric potential would be investigated by means of kites. Prof. G. H. Darwin regretted that on account of the non-existence of a Government meteorological observatory, this country is very backward in the adoption of recent methods of meteorological research. In a subsequent paper Mr. Rotch gave an account of the first crossing the Channel by a balloon, by Dr. Jeffries and M. Blanchard in January 1785. The former was a Harvard graduate in medicine, who settled in London, and the latter a French professional aëronaut. The expedition was of a scientific character.

A description of the hydro-aërograph, an apparatus invented by Mr. F. Napier Denison for registering small fluctuations of level of the American lakes and simultaneous small changes of air-pressure, was read by Mr. W. N. Shaw. The apparatus is designed to study more minutely an observed effect of barometric changes on the surfaces of the great American lakes.

The Ben Nevis committee presented the usual summary of their records, and stated that the conclusions arrived at last year with reference to the effects of approaching cyclones and anti-cyclones on the two observatories are supported by the examination of later records. The committee on meteorological photography reported having obtained photographs of some rare forms of cloud and some studies of lightning flashes; the structure of thunderclouds appears to resemble two parallel discs of cloud, with lightning flashes passing between them or from one face to the other of either cloud.

On Tuesday, Prof. Threlfall described a portable gravity balance, designed by Prof. Pollock and himself, for the measurement of small differences in the intensity of gravity from place to place. It consists of a light wire attached near one end to the centre of a horizontally stretched and twisted quartz fibre, the moment of the weight of the wire just balancing the torsional moment of the fibre. The wire is only just in stable equilibrium, and the torsion of the fibre is noted when the wire is adjusted to coincide with the axis of a microscope carried on the frame of the apparatus. The instrument can now be relied upon to 1 part in 500,000, but the accuracy of single readings is greater than this. It has been severely tested by much travelling on the Australian coast.

The committee on electric standards reported that Profs. Ayrton and J. V. Jones have now completed the plans and specifications for the ampere balance to be used in constructing an ampere standard. The committee will consider the proposals of Prof. Callendar for the construction of a standard platinum thermometer in terms of which all other platinum thermometers can be compared. The report contains the results of a determination of the coefficient of expansion of porcelain, by Mr. T. G. Bedford, which was undertaken in order to compare the scales of temperature and platinum thermometers of air.

Prof. Callendar opened a discussion on platinum thermometry, in which he advocated the adoption of the variation of resistance of platinum as a basis for a *practical* scale of temperature. He suggested the construction of a standard thermometer from a particular sample of platinum wire, and the use of a parabolic difference formula for the determination of temperature by its means. The difference-coefficient may be obtained by using as a secondary fixed point the boiling point of sulphur (444·53° C. at normal pressure). Dr. J. A. Harker described the method used, and Dr. Chappuis the results obtained, in a comparison of platinum and nitrogen thermometers at the International Bureau of Weights and Measures at Sèvres. The results agree fairly well with those of Callendar and Griffiths in the comparison of the air and platinum thermometers. In the discussion Mr. E. H. Griffiths advocated the use of the platinum thermometer on the ground that only three readings are necessary in order to standardise any instrument. Prof. Carey Foster was of opinion that the electrical method would furnish a good intermediate standard; for absolute values, however, the gas thermometer must be used, because there is no theory of the variation of electrical resistance with temperature and only an empirical knowledge of it. Prof. Burstall described experiments supporting the proposals of Prof. Callendar. Principal Glazebrook thought that, before taking platinum as a standard, experiments should be undertaken to ascertain whether it is superior to other metals, for instance gold. Dr. Chree said that some platinum thermometers purchased by the Kew Observatory had exhibited curious tricks, and were far from satisfactory, because the reasons for departure from accuracy were numerous and not always discoverable. In the case of mercury thermometers the zero certainly alters, but the change has a known cause, and can be allowed for. Prof. Threlfall remarked that for rapid and accurate work the platinum thermometer alone could be used; the enormous heat-capacity of a mercury thermometer rendering it quite unserviceable. Mr. W. N. Shaw thought the thermo-electric couple methods, upon which the Germans are concentrating their attention, ought to be compared with the platinum thermometer before deciding upon a standard. In reply, Prof. Callendar said that methods based on the use of a thermo-electric couple are not sensitive at low temperatures.

On Wednesday, Dr. L. A. Bauer described the arrangements made by the United States Coast and Geodetic Survey for the proposed magnetic survey of the United States and Alaska, and expressed a hope that the Canadian Government would consider the possibility of a simultaneous survey of Canada. Dr. Bauer also described the results of a magnetic survey of Maryland. Dr. E. P. Lewis, in a paper on the spectral sensitiveness of mercury vapour in an atmosphere of hydrogen, described the appearance and intensity of the spectrum of a mixture of hydrogen and vapour of mercury in varying proportions. Mr. J. Gifford, who has measured the angles of prisms of quartz and calcite, and the corresponding minimum deviations for the mean of the sodium lines, at various temperatures, gave an account of the variation of refractive index with temperature in these cases.

The proceedings of the Section closed with votes of thanks to the president and secretaries, proposed by Prof. Forsyth, and seconded by Prof. Reinold.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

OXFORD.—The following are among the lectures and practical courses announced for the present term:—General Pathology, Sir J. Burdon-Sanderson; The Chemical Processes of the Body, Prof. F. Gotch; Elementary Physiological Chemistry, W. Ramsden; Practical Histology, G. Mann; Elementary Medicine. W. Collier; Minor Surgery, A. Winkfield; Human Osteology, Prof. A. Thomson; Analytic Theory of Plane Curves, and Synthetic Theory of Plane Curves, Prof. W. Esson; Elementary Mathematical Astronomy, Prof. H. Turner; Physical Crystallography, Prof. H. Miers; Practical Crystallography, H. Bowman; Electricity and Magnetism, Prof. A. Love; Theory of Numbers, Prof. E. Elliott; General Morphology, and Variation Inheritance and Natural Selection, Prof. W. Weldon; Experimental Physics, Prof R. Clifton; Structure of Simple Machines, Rev. F. Jervis-Smith; Silicon and Boron Compounds, Prof. W. Odling; Subjects of the Preliminary Examination in Chemistry, Dr. W. Fisher; Organic Chemistry, J. Watts; Physical Chemistry, V. Veley; Metabolism, J. Haldane; Muscular Activity, Prof. F. Gotch; Physiological Physics, G. Burch; Physical Geology, and Jurassic Fossils, Prof. W. Sollas; Elementary Botany, Prof. S. Vines; Classification of Mankind by Race, Language and Civilisation, Prof. E. Tylor; Bacon, and the Organon of Aristotle, Prof. T. Case; Mental Evolution, G. Stout; Inference and Scientific Method, J. Cook Wilson.

CAMBRIDGE.—Mr. John Sealy Edward Townsend, who entered the University as an Advanced Student in Physics, was on October 9 elected to a Fellowship in Trinity College.

Dr. W. E. Dixon, late Salters' Research Fellow in Pharmacology, has been appointed Assistant to the Downing Professor of Medicine.

Dr. L. Humphry has been appointed Assessor to the Regius Professor of Physic.

A Scholarship of 50*l.* in Natural Science will be open for competition at Downing College to members of the University of less than four terms' standing on Monday, November 27. Applications are to be made to the Tutor.

Studentships for research have been awarded at Emmanuel College to R. G. K. Lempfert and B. W. Head.

A GENERAL meeting of Convocation of the University of London was held on Tuesday to receive an interim report from the special committee appointed on June 27 to make representations to and to confer with the London University Commissioners, the Senate, and other bodies with reference to the scheme of the Royal Commission. On the subject of faculties contemplated under Section 10 of the Schedule of the University of London Act, the special committee made various recommendations, among which the following may be noticed:—There should be only one faculty of science with adequate representation on the Senate and the Academic Council. Engineering should be a distinct branch of the one faculty of science and not a separate faculty, but degrees should be given in engineering bearing a distinctive name. If it should be thought expedient to constitute a distinct branch of the faculty of science for any other scientific profession, there is not, in the opinion of the committee, any present occasion for giving a distinctive name to degrees to be taken in that branch. If, contrary to the opinion of the committee, the subjects of the faculty of science should be divided by the commissioners, for electoral purposes, into several faculties, the committee hope they may be afforded an opportunity of giving further consideration to the principles upon which such division should be effected, especially in connection with the effect which the division would have upon the University examinations and degrees. After discussion it was decided "that the report be received subject to the reconsideration by the committee of such points, if any, as this house may deem advisable."

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, October 2.—M. van Tieghem in the chair.—The Mayor of Chantilly informed the Academy that the inauguration of the statue erected to the Duc d'Aumale would take place on October 15.—Orbit of the shooting star of August 24, by M. J. Comas Sola. This meteor, which was a very bright one, was observed at the Observatory of Catalá, had a relative direction nearly east to west, disappearing near α-Capricorn. Its absolute velocity was 50 kilometres per second. A similar meteor was observed on August 28 at 7.45, but of smaller lustre.—On the identity of solution of certain problems of elasticity and hydrodynamics, by M. Georges Poisson. In a note presented to the Academy on May 2, 1898, M. Maurice Lévy remarked that in problems of elasticity in two dimensions the distribution of the pressures is independent of the value of the elastic coefficients. In the present note it is shown that in this case the determination of the pressures may often be reduced to the study of the permanent motion of a liquid.—On two chlorobromides of tungsten, by M. Ed. Defacqz. In an attempt to prepare tungsten hexabromide, tungsten hexachloride was sealed up with liquid hydrobromic acid in excess, and the whole heated at 70° for four hours. The resulting product was not the desired hexabromide, but a chlorobromide having approximately the composition $WCl_6.3WBr_6$. In a second similar preparation the tube was not heated, but left for three days at the temperature of the laboratory; the substance obtained was another chlorobromide, represented by the formula $WCl_6.WBr_6$.—On copper hypophosphite and its decomposition by precipitated palladium, by M. R. Engel. Aqueous solutions of copper sulphate and barium hypophosphite are mixed in equal molecular proportions, the solution filtered, and the copper hypophosphite precipitated in the crystalline form by the addition of alcohol in excess. The solution of the salt is decomposed in a remarkable manner by the addition of precipitated palladium, copper being thrown down and hydrogen gas evolved according to the equation

$$Cu(PO_2H_2)_2 + 2H_2O = Cu + 2H_3PO_3 + H_2,$$

no copper hydride being formed. In the absence of palladium the copper hypophosphite is decomposed differently by heat, copper hydride being first formed, and then metallic copper, phosphorous and hypophosphorous acids.—Salicylic and para-oxybenzoic aldehydes and salicylhydramide, by MM. Delépine and Rivals. A thermochemical paper.—On a double monstrosity observed in the blastoderm of a fowl's egg in the course of formation, by MM. Bonmariage and Petrucci.—Completion of some observations on the Alps of the Vaudois, by M. Stanislas Meunier.—On an aërial voyage of long duration, from Paris to the Mediterranean, carried out on September 16 and 17, by M. Gustave Hermite.—Barometric deviations on the meridian of the sun on successive days of the tropical revolution of the moon, by M. A. Poincaré.

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