THURSDAY, MAY 13, 1886

THE CHEMISTRY OF THE COAL-TAR COLOURS

The Chemistry of the Coal-Tar Colours. Translated from the German of Dr. R. Benedikt, and Edited, with Additions, by E. Knecht, Ph.D. (London: George Bell and Sons, 1886.)

THIS is an excellent little practical manual dealing with a subject of great scientific and industrial importance—a subject the scientific side of which has been somewhat neglected in this country, to the inevitable detriment of the industrial side. The decline of this industry in England is a tempting subject to expatiate on; but the moral has of late been pointed with such laudable iteration that we refrain from pointing it afresh. The state of affairs which prevails with regard to the literature of the subject is expressed in the opening words of the editor's preface:—

"Although England may be called the birthplace of the coal-tar-colour industry, it is a remarkable fact that the English literature on the subject is very scanty, and that which does exist is now almost obsolete owing to the rapid strides which have been made during the last ten years in the manufacture of the coal-tar colours."

There is no doubt about the want, and we think that this little work supplies it to the extent aimed at. Both author and editor are specially qualified for their task by experience in teaching the technology of the subject.

The work contains excellent introductory chapters on the optical properties of colouring matters, the methods of testing colouring matters—both spectroscopically and with regard to their tinctorial power—on the relation of the various fibres to the colouring matters, and kindred general questions, of importance both to the colour chemist and to the dyer. "Rule-of-thumb" is everywhere excluded; reasons are fully and clearly given.

The greater part of the work is necessarily devoted to the chemistry proper of the coal-tar colours—the chemical processes by which the various colouring matters are obtained and the reactions by means of which a knowledge of their chemical constitution is arrived at. Constitutional formulæ naturally play a very important part.

Our modern dynamical chemists—some of whom, by the way, appear to be censors first and investigators afterwards—are never tired of crying out for the abandonment of these constitutional formulæ on the ground that they afford only statical, not dynamical, representations of chemical phenomena. Happily, those who have built up the German coal-tar-colour industry of the last fifteen years on the basis of the benzene theory have never shared this opinion; nor is it shared by our authors, who in their little treatise faithfully reflect the methods and results of this great scientific and industrial development. Doubtless, colour chemists would prefer a dynamical formula—one which should indicate, for example, the most suitable temperature at which to perform a potash fusion, or a nitration, with a few hints thrown in as to time of heating, concentration, and so forth—and doubtless the dynamical chemists will in time supply this want; but meanwhile the colour chemist feels, taught by experience, that his humble and inexact calculus of chemical operations, the constitutional formula, is vastly better than anything that has been offered in its stead. But as yet the dynamical critic does not appear to have anything to offer in its stead: like certain *dynamitical* critics he is satisfied with destruction, and his attitude towards constitutional formulæ is not unlike that of the dynamitical critic towards Constitutions—British and other.

There is little which calls for criticism in the chemical portion of the work: the classification is good, and the results of the elaborate investigations of which almost every colouring matter of any importance has of late years been made the subject are given briefly but in a way calculated to make clear to the beginner the significance of such work. We could have wished, however, that Dr. Knecht in his editorial capacity had thought good to give some account of the researches of O. Fischer on flavaniline and chrysaniline, and of Bernthsen on methylene-blue. The problem of the constitution of these compounds has been solved in a very instructive and conclusive fashion—much more conclusively than in the case of some of the colouring matters of which the constitution is discussed in the present work.

In the introduction reference is made to the popular prejudice which exists against the so-called "aniline dyes"—the collective name by which coal-tar colours are known among non-chemists. There is an impression that the tints are crude and glaring, and that the colours lack fastness. Certainly there are coal-tar colours which sin in all these respects. But there is a survival of the fittest here as elsewhere: the vulgar shades and fugitive colours are being weeded out and replaced by better. The accusations come most frequently from persons of an æsthetic turn, and it is perhaps too much to expect that the strenuous æsthete, living laborious days in the endeavour to improve his own taste and that of his neighbours, should be aware that the beautiful and permanent Turkey-red, which he so justly admires, is now a coal-tar colour, and that even indigo may be made from coal-tar. As regards "fastness" of colours, the ideas of the general public on the subject may perhaps be gauged by a speech which we remember reading, made some years ago by a Member of Parliament in distributing the prizes at a technical school. Seeking to inculcate the duty of thoroughness in work, and desirous at the same time to employ only such illustrations as would at once come home to every technologist, he said:—"But it would not be thorough work, for example, to daub a wall with untempered mortar, or *to dye with fast colours.*" Probably a life divided between politics and sport had not permitted him to realise that the fastness of colours is distinct from that of race-horses—or of youth!

Where there is so much to praise we regret to have to record a defect, but we think that hardly adequate care has been bestowed upon the proof-reading. The misprints are unnecessarily numerous, and must sometimes be very puzzling to a beginner, especially where, as is occasionally the case, they affect complicated formulæ. A list of errata is given, which, however, needs extension. Whether, for example, the chemistry of the average student of technology will be equal to the task of informing him that not sodium bisulph*ate* but sodium bisulph*ite* is employed in the preparation of soluble alizarin-blue, or that the three formulæ given on p. 70 in a preliminary account of the products from tar, and described as those of "the three isomeric di-nitrobenzenes," are in reality those of the three mono-nitrotoluenes—errata not corrected in the list—is open to doubt.

In conclusion, we cordially recommend the book. We trust that it will not only be made use of by students of technology as a useful introduction to the larger treatises in French and German, but that the ordinary student of organic chemistry will take the opportunity of making a closer acquaintance with a special branch of his subject, as fascinating from a scientific point of view as it is fertile in practical results. F. R. JAPP

JAPANESE HOMES

Japanese Homes and their Surroundings. By Edward S. Morse, Director of the Peabody Academy of Science. (London: Sampson Low, 1886).

ALTHOUGH Prof. Morse's connection with Japan has been comparatively short and interrupted, few men have done so much for scientific progress in that country. About ten years ago he first visited Japan in order to study certain forms of ocean life on its coasts, and, fortunately, was induced to accept the Chair of Zoology in the University of Tokio. While holding this office he did much to arouse an interest in the minds of his students for biological research, and he established a Biological Society, which is, we believe, still at work. By his discovery and thorough investigation of the shell-mounds at Omori, near Tokio, he stimulated prehistoric studies. His monograph on these mounds—although perhaps his theory as to the builders may not, on more extended examination, have proved tenable—was followed by a number of publications on the Japanese Stone Age, cave-dwellers, and the like; and in many less generally known directions his influence on the advance of science in Japan has been a beneficial and stimulating one. His first visit to Japan has been followed by two others, during which he visited all parts of the country, as well as other regions of Eastern Asia, and has collected material on a variety of matters. The present volume is a monograph on the house in Japan;—the different types of houses, their mode of construction, the uses of each part, the varieties in each from the roof to the foundation, the types and uses of household utensils, &c. The illustrations, which are beautiful, are also very numerous, being, on the average, about one to a page. Without them it would, indeed, be difficult for readers who are not well acquainted with Japanese houses to follow the descriptions. Many of these details Prof. Morse thinks it may soon be difficult, if not impossible, to obtain, and therefore like an old Japanese to whom he refers, and who "held it a solemn duty to learn any art or accomplishment that might be going out of the world, and then to describe it so fully that it might be preserved to posterity," he now describes and copies them for the benefit of future generations who may not have the opportunity of seeing these evidences of Japanese skill and sense of beauty. We do not apprehend that the Japanese will ever change so far as to substitute the jerry-builder for their own carpenters, and we do not think that their style of architecture will ever greatly alter, for the simple reason that they have now what, on the whole, is the fittest. Nevertheless we cannot but be grateful to Prof. Morse for making the Japanese house, inside and out, so familiar to English readers. His work is so clear and detailed that we see no reason why any one who feels so disposed should not be able to erect for himself a home in the Japanese style in England.

In the eighth chapter indications from the most ancient works in Japanese literature are collected together in order to catch a glimpse of what the Japanese house of a thousand years ago was like. It would be useless without a plan of the modern house before us, to refer to these beyond quoting Prof. Morse's conclusion that they are significant indications of the marked southern affinities of the Japanese, and he thinks that, from all we can gather relating to the ancient house of the Japanese, it would seem that certain important resemblances must be sought for in Annam, Cochin China, and particularly in the Malay peninsula—but not amongst the Ainos. This is another nail in the coffin of the theory of an ethnic relationship of the latter with the Japanese. On the whole, Prof. Morse's theory of the history of house development in Japan is a slow but steady progress from the rude hut of the past to the curious and artistic house of to-day—a house as thoroughly a product of Japan as is that of the Chinese, Corean, or Malay a product of these peoples, and differing from all quite as much as they differ from one another. It has just those features incorporated into it that might be expected from its physical proximity to, and historical relations with, China and Corea. The last chapter deals with the "neighbouring house"—that is, Corean, Chinese, Aino, and Loochooan houses. In this chapter the writer has fallen into a curious error in describing Hachijô Island as one of the Bonins. There is no more connection between the two than there is between Iceland and the Isle of Wight. Hachijô has from the earliest times been Japanese; it was at one time a place of exile for political offenders. The Bonins never belonged to Japan until within the last few years; as the name (*Bu* or *Mu Nin*, without people) implied, they were uninhabited, except by a few waifs and strays thrown up by the sea—Caroline Islanders, deserters from whalers and ships of war. The account of the visit to Hachijô, from which Prof. Morse quotes, was published some years ago in the *Transactions* of the Asiatic Society of Japan, and is of exceptional interest, for in this island may still be observed ancient Japanese customs which have long fallen into desuetude on the mainland. Thus the peculiar lustration ceremonies, the special parturition houses, &c., now found in Hachijô, are mentioned in ancient Japanese works as common to all Japanese. The difficulty of access to the island from the adjacent mainland on account of dangerous currents would explain the presence of this little oasis of antiquity. There is this excuse, however, for Prof. Morse's confusion of the Bonin Islands with Hachijô, that the expedition set out for the Bonins, but the writers about Hachijô went no farther than that island, and there, while awaiting the return of the steamer, collected the material for the paper in question.

ACOUSTICS, LIGHT, AND HEAT

Acoustics, Light, and Heat. By William Lees, M.A., Lecturer on Natural Philosophy, the Heriot Watt College, and Lecturer on Mathematics and Experimental Physics, Free Church Training College, Edinburgh. New and Enlarged Edition. (London and Glasgow: Wm. Collins, Sons, and Co.)

THIS is one out of many of the text-books which have been called into existence by the "May" Examinations of the Science and Art Department. Being written especially to meet the requirements of the student who wishes to pass these examinations, it is only brought up to the standard given in the directory of the Department, and may therefore for this purpose be useful. The fact that a new and enlarged edition is now appearing is certainly evidence that this is the case. To make it more serviceable, the questions of all the May Examinations in Subject VIII. from 1872 to 1885 are given.

Though the simple and numerous diagrams and the generally clear nature of the text give it a certain value as a text-book, it is by no means so free from faults and ambiguities as might be expected in a new edition.

It may be well to refer especially to a few places where alterations suggest themselves.

Figs. 19 and 20 show the contrast between a musical sound and a noise. Though it is explained that "noises are due to irregular vibration or a confused mixture of musical sounds which produce aërial waves of great complexity and wanting in periodicity," no explanation is offered of a peculiarity in the "curve of a noise" (Fig. 20), which in three places is actually made to slope backwards.

Some of the figures in optics are rather wanting in precision. Thus in Fig. 73, which shows a real image formed by a concave mirror, a pair of slightly diverging rays are made to cross between the mirror and the principal focus. Again, Fig. 77 shows a caustic on the surface of milk in a glass with its cusp reaching close to the centre. Fig. 103 shows the action of a refracting plate on a beam of light by the turning and approximation of successive wave-fronts. Those two wave-fronts which obliquely cut the surface are shown straight and partly swung round, as if they were rigid lines meeting with resistance at one end. It would surely have been better to have bent the line at the point of intersection, leaving all the wave-fronts and parts of a front outside the medium parallel to one another, and also all inside parallel to one another, but it is possible that wave-fronts, strictly speaking, are not intended.

The explanation of so important a thing as the achromatic lens can hardly be considered satisfactory. Owing to its brevity it is possible to give this in full. "This defect in a lens [the defect of chromatic aberration] is obviated by the combination of a double convex lens of *crown* glass, with a convexo-concave of *flint* glass (Fig. 122). The effect of the second lens is to re-blend the coloured rays which the first has produced, and at the same time such an amount of refraction is preserved as to bring the light to a focus." As nowhere is it directly pointed out that for the same degree of refraction flint glass produces more dispersion than crown, it is not difficult to imagine that a student might fail to form any very clear idea of the principle of the achromatic lens, nor is he likely to be materially helped by the figure (122), which certainly does not represent either the section or any other view of any achromatic lens that was ever made. If it were not for the section lines it would be a good perspective drawing of a short cylinder; the ellipse which appears to be the end of such a cylinder is really meant to show the crown lens in section, and the figure of uniform thickness by its side, as thick everywhere as the ellipse is in the middle, which seems to be the side of the cylinder, is meant for the section of the flint lens. Simplicity in a diagram is a thing to be desired, but there is more than simplicity here.

Very little is said about spectrum analysis; and its application to the measurement of the motion of the heavenly bodies in the line of sight is not even mentioned.

The general weakness of the optical part is to a certain extent compensated for by the chapters on polarisation, which have much to recommend them. There is here, however, a paragraph which requires explanation. "Now it is found that whatever quantity of polarised light there is for any incidence *other than the polarising angle* in the reflected beam, there is always the *same* quantity in the refracted beam. At the polarising angle, however, the refracted beam exhibits traces of polarisation." What is meant by this distinction is by no means clear.

Heat is more precisely and clearly treated than light, but here the general excellence is marred by an example to illustrate expansion in which the working out of the result shows that the obvious meaning of the question is not intended. What any one would understand by the words, "Find the length of a rod of brass which would expand equally with a rod of steel 3 feet long under a change of temperature of 10° C.," is evidently—Find what length of brass will increase in length by the same amount that a 3-foot rod of steel does for a change of 10° C. But what is found in the working of the answer is the length of a piece of brass which will expand so as to be *as long as* a piece of steel 3 feet long when each is *raised* 10° C.

Sufficient has been said to show that this book is not as clear and accurate in either the text or the figures as might be expected in a new edition.

OUR BOOK SHELF

Cholera Curable. By John Chapman, M.D. (London: Churchill, 1885.)

DR. CHAPMAN has had the opportunity of testing, in the Hôpital de la Charité in Paris, his method of the so-called neuro-dynamic treatment in Asiatic cholera, and his demonstration of the success of this treatment constitutes, we take it, the cardinal motive for the production of this book, although a good many other, mostly theoretical, considerations are brought into the discussion.

The symptoms of Asiatic cholera are explained by a number of assumptions on the action of the spinal cord and the sympathetic nervous system, but as to which we look in vain for experimental proof. The theories concerning the etiology and causation of cholera are fully treated, and then Dr. Chapman promises to furnish us with a complete solution of these problems in a discovery made by him as to the cause of cholera. When, however, we come to analyse what he really has discovered, it turns out that he himself is moving in a circle of fallacies. While denying the specific nature of the cholera virus, he explains this latter by the symptoms of the disease. Assuming, for the sake of argument, with Dr. Chapman, the particular disturbances of function in the cord and the sympathetic nerves to which the symptoms of cholera are due, how does this bring us nearer to the knowledge of what causes these particular disturbances? By saying, or even by showing, that such and such a disturbance in the function of the cord and sympathetic causes such and such a symptom of disease, we are not one iota nearer the answer to the question, Why did such and such a disturbance take place? what has caused it? The answer to this one wants to know, but this is not supplied by Dr. Chapman. It is quite true that a great many conditions are required to favour the outbreak and spread of cholera, *e.g.* conditions of temperature, water, atmospheric disturbances, soil, &c., &c., but all these conditions may be present without producing cholera, or typhoid fever, or any other similar disease. Why? Because *the actual cause* of the disease is absent. These two things, viz. secondary conditions favouring the outbreak and spread, and *the actual cause*, must be kept separate; but evidently Dr. Chapman has not arrived at this as yet.

The chapters VIII. to XV. describe the various methods of treatment of the disease, and they form the most important part of the book. E. KLEIN

Seaweeds, Shells, and Fossils. By Peter Gray, A.B.S., and B. B. Woodward. (London: Swan Sonnenschein and Co

THE object of this book is to give to the young English collector a general knowledge how to set about collecting the more common seaweeds, shells, or fossils.

In the first case the subject is dealt with generally, classifying the different seaweeds and stating where each is most likely to be found, and, when found, the best way to press them and get them ready for the cabinet, the most economical way of making or obtaining which is given.

Secondly, shells are dealt with, descriptions and diagrams being added where necessary, together with a table of the more important genera, showing the approximate number of species belonging to each genus, and their distribution.

Thirdly, and lastly, different localities are pointed out where fossils are best found, and the best mode of arranging them in the cabinet. A table of the principal fossiliferous strata arranged in chronological order, with notes on the different formations mentioned in the table, and also of the principal divisions of the animal kingdom, are added to show the order in which the fossils should be arranged. S.

The Modernised "Templeton"; or, "The Practical Mechanic's Companion." By William Templeton. Revised and Modernised by Walter S. Hutton, C.E. (London: Crosby Lockwood and Co., 1886.)

TEMPLETON'S "Mechanic's Workshop Companion" is a work familiar to most mechanics and draughtsmen, having been considered for the last quarter of a century a useful book of reference by all connected with the management of engineering workshops and kindred trades. Books of this description require revising very often, and considering the enormous development of the mechanical sciences during the last few years no one will wonder on hearing that even "Templeton" has to be modernised to keep pace with the times.

The reviser tells us that he has endeavoured to follow as far as possible the lines of the original work, at the same time bringing all the information up to date. Much new matter has been added, giving information on air, gas, water, and steam; methods of testing steam-engines and boilers; turbines and other water motors; the strength and weights of material; and miscellaneous information too numerous to give in detail.

The work has for a frontispiece an illustration of the fine compound locomotive "The Marchioness of Stafford," designed by Mr. F. W. Webb, the able locomotive superintendent of the London and North-Western Railway. On seeing this we are at once led to imagine that at last we have found a book giving recent data on locomotive engineering, and likely to fill a want seriously felt by those who study that most interesting branch of mechanical engineering. We are told to "see p. 360," to which we turn hoping to find a section devoted to locomotive work, having Mr. Webb's fine engine as an example of the latest advance. We find a third of a page giving the bare dimensions of the compound. Even the index makes matters no better, for the book contains no locomotive data whatever! Considering the thousands of mechanics engaged in this class of work, this is a great pity, and should be remedied in a future edition.

An excellent abstract is given of the results of experiments on riveted joints, with special reference to practical work, by Prof. Alexander B. W. Kennedy. This is most interesting and useful, and will well repay careful study by those connected with the manufacture of soft steel boilers and bridges.

The book contains all the usual tables, embracing every subject likely to be required by the intelligent mechanic or draughtsman, including extensive practical rules and data. Instruction is also given in the rudiments of arithmetic, algebra, and trigonometry. N. J. L.

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. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Foreign Fishery Boards

IN reference to recent statements in NATURE on this subject, it will interest your readers to know that in Italy the Government has constituted a Fishery Board, which, my friend Prof. Giglioli, of Florence, tells me, is actively employed in advising the executive and in inquiring into the grievances and difficulties of fishermen, and the suggestions for improvement of fisheries; it has also recently, at the expense of the Government, taken practical measures in the stocking of lakes with fish, and in the cultivation of sea-fish. This Commission is a branch of the "Ministry of Agriculture, Industry, and Commerce," which corresponds to our Board of Trade. *The members of the Fishery Commission, with the exception of the first three named below, are exclusively scientific men.* They are as follows:—The Permanent Under-Secretary of State for Agriculture; the Permanent Under-Secretary of State for Commerce; a distinguished lawyer; M. Minni, of Venice; Dr. Renier, of Chioggia (representing the fishermen of this island); M. Friedlander, of Comacchio (specially acquainted with the peculiar fish-culture of this district); Prof. Giglioli, Florence: Prof. Targioni-Tozzetti, Florence; Prof. Costa, Naples; Prof. de Vincentis, Taranto; Prof. Canestrini, Padua; Prof. Pavesi, Pavia; Prof. Issel, Genoa.

The Commission meets from time to time in Rome. The questions submitted to it are brought forward and referred separately to one or two members, who are requested to draw up a report on the particular subject thus referred. The report may take several months, and involve experiment or research, or it may be a simple matter. The report when presented is discussed by the whole Commission. The conclusions and recommendations which it embodies are modified by vote of the majority, and it is obvious from the constitution of the Board that the scientific experts have the voting strength.

The members of the Board or Commission are paid travelling expenses and 25 francs a day each during its sessions in Rome, or other fixed place of meeting.

The constitution of this Board is admirable, since it secures a fair representation of the leading scientific men of Italy. The Italian Government does not, it seems, refer such questions exclusively to one individual, but endeavours to obtain a consensus of the scientific opinion of the country.

Hôtel de la Ville, Florence — E. RAY LANKESTER

Fabry's Comet and Barnard's Comet

NOT having seen any mention of the rapid apparent growth of the tail of Fabry's comet, probably some of your readers are not aware to how great a length it extended. On April 26 occurred the first fine night after a very unusual series of overcast ones, and about 14h. G.M.T. I was surprised to see the tail reaching up to, or at least to within 1° of, δ Cassiopeiæ, a distance of 38° from the place given in the ephemeris for the nucleus, which was far below the horizon; and the tail would doubtless have been visible to a greater distance but for the brightness of the Milky Way. The following night, about 10h., it reached at least up to the Cluster in Perseus, a distance also of 38° from the predicted position of the nucleus; it was very narrow both nights. The next night, which was pretty fine, I failed to find any trace of the tail.

The principal tail of Barnard's comet is also very narrow: on May 1 its length was 4½°, as seen with a pair of field-glasses. With the telescope this comet had also a faint tail *nf*, about 16′ long, making an angle of 65° or 70° with the other.

Sunderland, May 7 — T. W. BACKHOUSE

"Pumice on the Cornish Coast"

STEAMER-CINDERS, similar to those referred to by Mr. Whitaker in NATURE for April 29 (p. 604), occur frequently on the Falmouth beaches; but as there seemed to me little probability of their being mistaken for pumice, I did not refer to the matter in my communication to your columns (April 15, p. 559).

Mr. Murray tells me that the pumice I found is felspathic, and that from its form and diminished buoyancy it had evidently been a long time in the water. The fragment was sent by him to Mr. Whitaker, who at once recognised its true character and its distinction from the steamer-cinders observed by him on the Suffolk coast, one of which he sent to Mr. Murray to satisfy him as to their very evident source. — H. B. GUPPY

95, Albert Street, Regent's Park, N.W., May 8

THE VELOCITY OF LIGHT

I.

[A reinvestigation of this important constant has recently been published by Prof. Newcomb. Before we state his methods and results we think it well to reproduce the following admirable historical notice with which his monograph commences.—ED.]

WHEN it became clearly understood that vision was not an immediate perception of objects by the eye, but was produced by the passage of an entity called light from the object to the eye, the question of the time which might possibly be required for this passage became one of interest to physical investigators. The first proposal for an experimental investigation of this question is due to Galileo.[1] He suggested that two observers, each holding a lantern, should be stationed at a distance apart, in sight of each other. Each should be supplied with a screen, by which he could, in a moment, cover or uncover his lantern. One observer should then uncover his lantern and the other uncover the other the moment he perceived the light from the first lantern. The interval which elapsed after the first uncovered his light, until he perceived the light of the second, would be the interval required for the light to go and come, plus the time required for the second observer to perceive the light and make the required movement. This experiment was tried by the Florentine Academy, and of course resulted in a conclusion that the time required was insensible, since we now know that it was far below any interval that could have been detected by so rude a method.

¹ Poggendorff, *Geschichte der Physik*, p. 402, where reference is made to he *Saggi* of the Florentine Academy.

It is, however, interesting to notice that, rude though this experiment was, the principle on which it was based is the same which underlies one of the most celebrated methods used in recent times for the attainment of the same object. Two very simple improvements which we might have imagined the Academicians to make in their experiments are these:—

Firstly, to dispense with the second observer, and in his place to erect a mirror, in which the first observer could see the image of his own lantern by reflection. The time required for the second observer to perceive the light and uncover his lantern would then have been eliminated from the problem. The interval sought would have been that between the moment at which the observer uncovered his lamp and the moment at which he perceived the reflection.

Secondly, to use the same screen with which he uncovered his own lamp, to cut off the returning ray from the distant mirror, and thus obviate the necessity of an uncertain estimate of the interval between his muscular effort in removing the screen and his perception of the return flash of light. If the image was perceived before he could cover his own eye with the screen removed from the lamp, it would show that the interval of passage was less than the time required to make a motion with the screen. This interval might have been reduced almost indefinitely by having both lines of sight as near together as possible.

Had these improvements been made, the Academicians would have had, in principle, Fizeau's method of measuring the velocity of light by the toothed wheel, a tooth being represented by the screens. To realise the principle more fully, the two lines of sight should have been rendered absolutely coincident by reflection through a telescope. It does not, however, appear that any effort to put the question to a severer test was made until the subject was approached from a different point of view. It was probably considered that the passage was absolutely instantaneous, or, at least, that the velocity was above all powers of measurement.

The subject was next approached from the astronomical side. In 1676 Roemer made his celebrated communication to the French Academy, claiming that observation of the eclipses of the first satellite of Jupiter did really prove that light required time to pass through the celestial spaces.[1] He found 11m. to be the time required for light to pass over a distance equal to the radius of the earth's orbit. Dominique Cassini, while admitting that the hypothesis of Roemer explained the observed inequality, contested its right to reception as an established theory, on the ground that the observed inequality might be a real one in the motion of the satellite itself.[2]

Continued observation showed that the time assigned by Roemer for the passage of light between the earth and sun, or "the light equation" as it is briefly called, was somewhat too great. In 1809 it was fixed by Delambre at 493·2s., from an immense number of observations of eclipses of Jupiter's satellites during the previous 150 years. This number has been received as a definitive result with a degree of confidence not at all warranted. In 1875, Glasenapp, then of Pulkowa, from a discussion of all available eclipses of Jupiter's first satellite between 1848 and 1870, showed that results between 496s. and 501s. could be obtained from different classes of these observations by different hypotheses.[3]

¹ *Paris Memoirs*, tome i. p. 212, and tome x. p. 575.

² *Ibid.* tome viii. p. 47. Poggendorff (*Geschichte der Physik*, p. 656) quotes Maraldi as also contesting Roemer's explanation on the ground that a similar inequality should be found depending on the position of Jupiter in his orbit. The ground here taken was quite correct, the only fallacy being the assumption that such an inequality did not exist.

³ This paper of Glasenapp's was published only in the Russian language as an inaugural dissertation, and in consequence has never become generally known.

As not a trace of Delambre's investigation remains in print, and probably not in manuscript, it is impossible to subject it to any discussion.[1]

The discovery of aberration by Bradley afforded an independent and yet more accurate method of determining the light equation. We call to mind that the latter constant, and that of aberration, are not to be regarded as independent of each other, but only as two entirely distinct expressions of the same result. The constant of aberration gives a relation between the velocity of light and the velocity of the earth in its orbit from which, by a very simple calculation, the time required for light to pass from the sun to the earth may be deduced.

It is remarkable that the early determinations of the constant of aberration agreed with Delambre's determination of the light equation, although we now know they were both in error by an amount far exceeding what was at the time, supposed probable. Struve's value, 20″·445, determined in 1845 from observations with the prime vertical transit of Pulkowa, has been the standard up to the present time. The recent determinations by Nyrén being founded on a much longer series of observations than those made by Struve, and including determinations with several instruments, must be regarded as a standard at present. His result is :—[2]

Definitive value of the constant of aberration = 20″·492 ± 0″·006.

At the time Struve's result was published there was an apparent difference of 1 per cent. between its value and that of the light equation determined by Delambre. The question then naturally arose whether the light equation, deduced on the hypothesis that the tangent of the angle of the constant of aberration was the ratio of the velocity of the earth in its orbit to the velocity of light, might not need correction or modification. This question cannot yet be considered as definitely settled, since the modifications or corrections might arise from a variety of causes. One of these causes is connected with a very delicate question in the theory of the luminiferous medium; a question which can be most clearly understood when placed in the following form :—It is a result of optical principles that a ray falling perpendicularly upon the bounding surface of a refracting medium retains its direction unaltered. Now, if this surface is carried along by the motion of the earth, and the light comes from a star, and it is desired that this surface shall be so directed that there shall be no refraction, must it be placed perpendicular to the *true* direction of the star as freed from aberration, or to its *apparent* direction as affected by aberration? The difference of the two directions may exceed 20″, and since the index of refraction of glass exceeds 1·5, there will be a difference of more than 10″ in the direction of the refracted ray, according as we adopt one or the other hypothesis. Assuming that the standard direction would be perpendicular to the true or absolute direction of the star, it is easily shown that the constant of aberration determined in the usual way would be too large by a quantity depending on the ratio of the thickness of the objective to the focal length of the telescope. In an ordinary telescope the difference would be nearly one-hundredth of the total value of the aberration, and would, therefore, closely correspond to the discrepancy between Delambre's result from the satellites of Jupiter and the modern determinations of the constant of aberration. The question of this particular cause was set at rest by Airy's experiments with a telescope filled with water, which showed that the result was independent of the thickness of the objective, and, therefore, that the apparent direction of the star was that on which refraction depended.

If, in accordance with the undulatory theory of light, we suppose the hypothetical entity called "the luminiferous medium" to be a substance, each part of which has its own definite and fixed location in space, then we must conceive that another unknown quantity may enter into the problem, namely, the motion of the heavenly bodies through this medium. We have relative motions in the solar system, exceeding 50 kilometres per second, and possibly greater relative motions among the stars. Now it is clear that the heavenly bodies cannot all be at rest relative to the medium, but must move through it with velocities at least of the order of 50 kilometres per second, and possibly greater without limit, since it is conceivable that the whole visible universe might be moving in a common direction relative to the medium.

It is easily seen that if we suppose the velocity of the earth, through the medium, to have a small ratio, a, to the velocity of light, then the observed constant of aberration may be altered by an amount found by multiplying its value by a quantity of the order of magnitude of a. This alteration would be entirely insensible if the earth does not move through the medium with any greater velocity than it does around the sun, since the value would then be only $\frac{1}{10000}$. It is remarkable that so far as yet investigated every optical effect arising from such a motion, which could be measured on the surface of the earth, is of the order of magnitude of the square of a. Thus, no phenomenon has yet been discovered which can be traced to the motion in question.

Assuming that there is no general motion of the solar system through the ether of a higher order of magnitude than that of the relative motions of the fixed stars to each other, and that the ordinary theory of aberration is correct, there will be three constants between which a relation exists, such that when any two are found the third can be determined. These constants are :—

1. The distance of the sun in terrestrial units of measure;

2. The velocity of light in units of the same measure; and

3. The constant of aberration, or, which is supposed to be equivalent, the light equation.

Until our own time the first and third constants were used to determine the second. From the fact that light required about 500 seconds to traverse the distance from the sun to the earth, and that the distance of the sun was, as supposed, 95,000,000 of miles, it was concluded that light moved 190,000 miles per second. The hopelessness of measuring such a velocity by any means at the command of physicists was such that we find no serious attempt in this direction between the date of the futile effort of the Florentine Academy, and that of the researches of Wheatstone, Arago, Fizeau, and Foucault nearly two centuries later. One of the most curious features presented by the history of the subject is that two entirely distinct methods, resting on different principles, were investigated and put into operation almost simultaneously. The revolving mirror of Wheatstone, and its application to determine the duration of the electric spark and the velocity of electricity, come first in the order of time. But, before this ingenious instrument had been applied to the actual measurement of the velocity of light, Fizeau had invented his toothed wheel, by which the same object was attained.

Fizeau's paper on the subject was presented to the Academy of Sciences on July 23, 1849.[1] We have already shown that his method and that of Galileo rest fundamentally upon the same principle. The arrangement of his apparatus was substantially as follows :—

A telescope was fixed upon a house at Surésne pointing to the hill Montmartre. On this hill was a second fixed telescope looking directly into the first, the distance between them being about 8633 metres. In the focus of this second telescope was fixed a small reflector, so that

[1] The author could find no remains of this investigation among Delambre's papers at the Paris Observatory.

[2] *Mémoires de l'Académie Impériale des Sciences de St. Pétersbourg*, vii. série, tome xxxi. No. 9.

[1] *Comptes rendus*, vol. xxix. 1849, p. 90.

a beam of light from the first would be reflected directly back to it. By means of a transparent glass, fixed in the eye-piece at an angle of 45°, a beam of light was sent from the first telescope to the second, and, on its return through a total distance of 17 kilometres, could be seen as a star by an eye looking through the first. Alongside the eye-piece of the latter a revolving wheel, with 720 teeth cut upon its circumference, was fixed in such a way that the beam of light both in going and coming had to pass between the teeth. When the wheel was set so that the tooth was in the focus, the beam would be entirely cut off in its passage through the telescope. Changing the position of the wheel through half the space between the middles of two consecutive teeth, the light would go and come freely between the teeth. When the wheel was set in revolution a succession of flashes would be sent out. If, on the return of each flash, a tooth was interposed, it would be invisible to the eye looking through the telescope. Fizeau found that with a velocity of 12·6 turns per second each flash which went out was on its return cut off by the advancing tooth. With a velocity twice as great as this it was seen on its return through the opening next following that through which it went. With three times this velocity it was caught on the second tooth following, and so on.[1]

This experiment of Fizeau was soon followed by the application of the revolving mirror of Sir Charles Wheatstone. Shortly after measuring the duration of the electric spark this investigator called attention to the fact that the same system could be applied to determine the velocity of light, and especially to compare the velocities through air and through water. In 1838 the subject was taken up by Arago, who took pains to demonstrate that it was possible, by the use of the revolving mirror, to decide between the theory of emission and that of undulations by determining the relative velocities in air and in a refracting medium.[2]

The difficulties in the way of securing the necessary velocities of the mirror and of arranging the apparatus were such that Arago never personally succeeded in carrying out his experiments. This seems to have been done almost simultaneously by Foucault and Fizeau about the beginning of 1850. Both experimenters seem to have proceeded substantially on the same principle and to have reached the same result, namely, that the motion of light through water was slower than through air in the inverse proportion of the indices of refraction of the two media.[3]

An important and most necessary modification of Arago's plan was made by these experimenters. As originally proposed, the plan was to send an instantaneous flash of light through water and through the air, and to receive it on the revolving mirror and determine the relative deviations in the positions of the images produced by the two rays. This system would, however, be inapplicable to the measurement of the actual time of transmission, owing to the impossibility of making any comparison between the time at which the flash was transmitted, and that at which it was received on the mirror. This circumstance would, indeed, have rendered the actual realisation of Arago's project nearly impossible for the reason that the flashes of light, seen through the water, would have reached the mirror at every point of its revolution; and only an exceedingly small fraction of them could have been reflected to the eye of the observer.

This difficulty was speedily overcome by Foucault and

[1] It is curious that the author's account of this remarkable experiment, which forms an epoch in the history of physical science, is contained within the limits of two pages, and terminates without any definite discussion of the results. It is merely stated that the result is 70,948 leagues of 25 to the degree, but the velocity, in kilometres, which must have been that first obtained, is not given, nor is it stated what length the degree was supposed to have in the computation.

[2] *Comptes rendus*, 1838, vol. vii. p. 954; *Œuvres de François Arago*, vol. vii. p. 569.

[3] *Comptes rendus*, xxx. 1850, pp. 551 and 771.

Fizeau by a most ingenious arrangement, of equal importance with the revolving mirror itself. Instead of sending independent flashes of light to be reflected from the mirror, a continuous beam was first reflected from the revolving mirror itself to a fixed mirror, and returned from the fixed mirror back on its own path to the revolving one. A succession of flashes was thus emitted as it were from the fixed mirror, but their correspondence with a definite position of the revolving mirror was rendered perfect. Moreover, by this means, the image was rendered optically continuous, since a flash was sent through and back with every revolution of the mirror, and after the velocity of the latter exceeded 30 turns per second, the successive flashes presented themselves to the eye as a perfectly continuous image.

It was not until 1862 that this system was put into operation by Foucault for the actual measurement of the velocity of light through the atmosphere. A new interest had in the meantime been added to the problem by the discovery that the long-accepted value of the solar parallax was too small, and that the measurement of the velocity of light afforded a method of fixing the value of that constant. The central idea of the method adopted by Foucault was that already applied in comparing velocities through different media. The element sought is made to depend upon the amount by which the revolving mirror rotates while a flash of light is passing from its surface to the distant reflector, and coming back again. As the details of Foucault's method will be best apprehended by a comparison of them with those adopted in the present investigation, a complete description of his apparatus will here be passed over. It may, however, be remarked, that what he sought to observe was not the simple deviation of a slit, but the deviation of the image of a reticule. The deviation actually measured was 0·7 millimetre, and the system adopted was to determine at what distance, with a definite velocity, this amount of deviation could be obtained. His result for the velocity of light was 298,000 kilometres per second.

The next measures of the element in question were those of Cornu. The method which he adopted was not that of the revolving mirror, but Fizeau's invention of the toothed wheel. His earlier measures, made in 1870, and communicated to the French Academy in 1871, led to a result nearly the same as that of Foucault.[1] This result was, however, not so satisfactory that the author could record it as definitive. He, therefore, in 1874, repeated the determination on a much larger scale and with more perfect apparatus. The distance between the two stations was nearly 23 kilometres, and therefore much greater than any before employed. He was thus enabled to follow the successive appearances and extinctions of the reflected image to the thirtieth order; that is, to make fifteen teeth of his wheel pass before a flash returned from the distant reflector, and to have it stopped by the sixteenth tooth.

This method has a defect, the result of which is evident by an examination of Cornu's numbers. It is that the extinctions and reappearances of the light as the wheel changes its speed are not sudden phenomena, occurring at definite moments, but are so gradual that it is difficult to fix the precise moment at which they occur. Of this defect the able experimenter was fully conscious, and his discussion of the disturbing causes which come into play, and of the amount of error due both to the apparatus, the observer, and to the method of eliminating them, form altogether one of the most exhaustive discussions of a physical problem.[2] But the uncertainties are not of a kind which admit of complete investigation, and it now appears that although his result was far superior in point of accuracy to that of Foucault, it was nevertheless in error by about 0·0015 of its whole amount. It was, in

[1] *Comptes rendus*, vol. lxxiii. 1871, p. 857.

[2] Annales de l'Observatoire de Paris, *Mémoires*, tome xiii.

fact, when reduced to a vacuum, 300,400 kilometres per second, while we may now regard it as well established that the true velocity is less than 300,000.

The next determination of the velocity of light was that of Michelson,[1] whose result was 299,910 kilometres per second. His investigation being a part of the first volume of the present series need not be here discussed, but it is worth while to remark that his method seems far superior in reliability to any before applied.

An attempt has been made by Messrs. James Young and George Forbes to improve Fizeau's method, by diminishing the uncertainty arising from the gradual extinction of the visible image.[2] By the method of these experimenters the result depends, not upon the moment when the image disappears, but when two images, side by side, are equal in brightness. This is effected by employing two reflectors, at unequal distances, but nearly in the same line from the telescope, to return the ray. Each reflector then forms its own image in the field of view of the sending telescope. With a regularly increasing velocity of the toothed wheel, each image goes independently through the same periodic series of changes as when only one mirror is used; but owing to the unequal distance the period is not the same. If the speed of the mirror be carried to such a point that the difference of phase in the two images is half a period, then one image will be increasing while the other is diminishing, and the stage at which the two images are equal would appear to admit of fairly accurate determination.

The distant reflectors were separated from the observing telescope by the Firth of Clyde. The distances were respectively 16,835 feet, and 18,212 feet. A study of the printed descriptions of their experiments gives the impression that the performance of the subsidiary parts of the apparatus was not such as to do justice to the method. The resulting velocity of light was 301,382 kilometres per second, and the difference between the extreme results of twelve separate determinations was 4000 kilometres.

The most important result of the work of these gentlemen, could it be accepted, would be the establishment of a difference between the velocities of differently-coloured rays. We may regard it as quite certain, from the absence of any change in the colour of the variable star, β Persei, while it is increasing and diminishing, that the difference between the times required by red and by blue rays to reach us from that star cannot exceed a moderate fraction of one hour. It is quite improbable that its parallax is more than 0″·1, and therefore probable that its distance is 2,000,000 or more astronomical units. The possible difference between the velocities in question can, therefore, only be a small fraction of the hundred-thousandth part of either of them. No apparatus yet devised would suffice for the measurement of a difference so minute, and we are justified in concluding that the phenomena observed by Messrs. Young and Forbes arose from some other cause than a difference between the velocities of red and blue rays.

The present determination had its origin as far back as 1867. In his "Investigation of the Distance of the Sun," published in that year, the author introduced some remarks upon Foucault's method, and pointed out the importance to the determination of the solar parallax of repeating the determination of Foucault on a much larger scale, with a fixed reflector placed at a distance of three or four kilometres.[3]

From that time forward the subject excited the attention of American physicists, several of whom formed plans, more or less definite, for executing the experiments. As, up to the year 1878, no important steps in this direction had been taken, the author, in April of that year, brought the subject before the National Academy of Sciences, with the view of eliciting from that body an expression of opinion upon the propriety of asking the Government to bear the expenses of the work. The subject was referred to a Select Committee, who, in January, 1879, made a favourable report on the subject, which was communicated to the Secretary of the Navy. On the recommendation of the Secretary, Hon. R. W. Thompson, Congress, in March following, made an appropriation of $5000 for the purpose, and the author was charged by the Department with the duty of carrying out the experiments.

In the meantime it became known that Mr. Michelson had made preparations for repeating Foucault's determination at his own expense, with the desirable improvement of placing the fixed reflector at a considerable distance. But before the reliability of Mr. Michelson's work had been established, the preparations for the present determination had been so far advanced that it was not deemed advisable to make any change in them on account of what Mr. Michelson had done. The ability shown by the latter was, however, such that, at the request of the writer, he was detailed to assist him in carrying out his own experiments, and acted in this capacity until September 1880, when he accepted the Professorship of Physics in the Case Institute, Cleveland, Ohio. After the departure of Mr. Michelson his place was taken by Ensign J. H. L. Holcombe, U.S.N., who assisted in every part of the work to the entire satisfaction of the projector until its close.

[1] "Astronomical Papers of the American Ephemeris," vol. i. part iii. Owing to an error in applying one of the corrections the result was given as 299.912 kilometres.

[2] *Philosophical Transactions* for 1882, p. 231.

[3] Washington Observations, 1865. Appendix ii.

PANCLASTITE

DR. SPRENGEL has sent us a reprint of a note sent by him to the *Chemical News* on this subject. After showing that these new explosives, so named by Mr. Turpin, are not original, he continues:—

"The 'beau idéal' of a detonating explosive is a mixture of 8 parts (88·9 per cent.) of liquid oxygen and 1 part (11·1 per cent.) of liquid hydrogen.

"In my paper of 1873 I say, p. 799:—'On referring to the foregoing table the reader will be reminded that peroxide of hydrogen is the highest oxygen compound known, while nitric anhydride is the compound which contains the largest amount of oxygen available for combustion (74 per cent.). But as this compound, as well as the next two, nitric peroxide (69·5 per cent. oxygen) and tetranitromethane (65·3 per cent. oxygen) are: at present: on account of their nature and their difficult preparation, mere chemical curiosities, my attention naturally turned to the fourth, to *nitric acid* (63·5 per cent. oxygen), which is a cheap and common article of commerce.'

"Now, when Mr. Turpin's attention turned to the second oxidiser on my list—to nitric peroxide—he found that this substance does *not corrode* metals, such as iron, copper, and tin under 356° F. (180° C.); and further, that combustible liquids, such as petroleum, carbon bisulphide, and nitro-benzene are readily soluble in nitric peroxide *without* rise of temperature. These are valuable properties, *first noticed by Mr. Turpin.*

"What was formerly a chemical curiosity is now an article of commerce. Nitric peroxide may be bought to-day at eighteenpence the pound, and I see ways and means of producing it a great deal more cheaply. Nitric peroxide is a yellowish liquid, heavier than water (sp. gr. = 1·451), and boils at 71° F. (22° C.), but may be kept like ether or similar volatile liquids. In France it is sent about in tinned-iron cans.

"Taking as a typical example a benzene-mixture—

$$\begin{array}{rcl} C_6H_6 = 18{\cdot}4 = & \left.\begin{array}{r} 17{\cdot}0\ C \\ 1{\cdot}4\ H \\ 56{\cdot}8\ O \end{array}\right\} & = \begin{array}{l} 62{\cdot}6\ CO_2 \\ 12{\cdot}6\ H_2O \end{array} \\ 7\tfrac{1}{2}(NO_2) = \underline{81{\cdot}6} = & 24{\cdot}8\ N & \\ 100{\cdot}0 & & \end{array}$$

we see, that the 18·4 parts of benzene require 56·8 parts of oxygen for the oxidation of their carbon and hydrogen to carbonic acid and water. This oxidation or combustion takes place at the moment of explosion at the expense of the 56·8 parts of oxygen, contained in the rest of the mixture—the 81·6 parts of nitric peroxide. No other explosive now in use (including blasting gelatin) contains weight for weight a greater amount of combustible matter, and as an explosion of *these* bodies is simply a sudden combustion, I again beg to draw attention to the fact that the oxygen available for combustion in gun-cotton is most probably not more than 32·3 per cent. and in nitroglycerin 42·3 per cent.,[1] while in this case we have without a doubt 56·8 per cent. Hence no other explosive now in use can rival this and similar mixtures in power, as I published in 1873. They still remain *the most powerful* explosives known.

"It hardly need be said that an explosive of this nature consists of two parts—an oxidising and a combustible agent—and that Mr. Turpin with the same *naïveté* lays claim not only to the first, but also to the latter half of the subject.

"None of my *safety*-explosives are licensed in England, though many of them, when mixed, are much less sensitive to concussion than common gunpowder.

"In April 1884 the French military authorities were busy near Rochefort with shells of the 'système Turpin.' These shells, so my informant said, were made of such a size, and possessed such a prodigious power, that a ship struck by one of them would inevitably be sent to the bottom of the sea, even were she the strongest ironclad afloat. It is devoutly to be hoped that those whose office it is to provide for the defence of the British Navy *will be ready* in the hour of need to serve out shells, filled with an explosive of equal force or better still with something superior, approaching more closely the 'beau idéal.'"

MR. VERBEEK ON THE KRAKATÃO DUST-GLOWS

AS it appears from the letter of Mr. Douglas Archibald in NATURE of April 29 (p. 604) that some doubt exists as to the quantity of volcanic dust ejected during the Krakatão eruption in 1883, it may not be inopportune to give an abstract of what Mr. Verbeek—the best authority on the subject—says in the second part of his book. The mistake in the number of cubic kilometres—which Dr. Riggenbach or his critic magnified from 18 into 150—may possibly have arisen from the comparison Mr. Verbeek draws between the quantity of volcanic substances ejected by the Tambora in 1815 and that ejected by Krakatão.

Junghuhn estimated the quantity of ashes ejected by the Tambora in Sumbawa at 318 cubic kilometres, but Mr. Verbeek reduces it by calculation to about 150, though he adds that the data are insufficient to form a really correct estimate. It is certain, however, that the quantity was considerably larger than that ejected by Krakatão. To calculate this quantity Mr. Verbeek made observations everywhere on the islands and along the coasts of the Straits of Sunda; while the thickness of the ashes which fell into the sea was computed according to the difference in the depths of the sea before and after the eruption, a difference which greatly varies, and amounts in some places to 40 metres, if not more. Wherever some doubt exists for want of previous accurate deep-sea soundings, Mr. Verbeek gives the lowest figures. These observations are all illustrated by maps. Mr. Verbeek estimates the quantity of ejected material which fell round the volcano at 18 cubic kilometres at least. The possible outside margin would, however, not exceed 3 cubic kilometres. Of this quantity, two-thirds, or 12 cubic kilometres, lies within a circle with a radius of 15 kilometres drawn round Krakatão, one-third, or 6 kilometres, outside it. Of the finer ashes a large quantity were already, during the first three days, blown into the sea, as appeared from observations made on ships; and Mr. Verbeek assumes that considerably less than 1 cubic kilometre remained floating in the upper regions of the atmosphere. This quantity would correspond to a layer of 0·002 millimetre thickness divided over the whole surface of the earth, or of 0·004 millimetre over the temperate zones only.

Such an infinitesimally thin layer could hardly have been the principal cause of the atmospheric phenomena. They must be accounted for in a great measure by the large volume of aqueous vapour ejected by Krakatão, the amount of which lies, unfortunately, beyond all calculation. We have to deal with two distinct phenomena, as Prof. Michie Smith also has shown by the two different spectra, and these phenomena had different causes: thus, the blue and green tints of sun and moon, which were specially observed during the first month after the eruption, and only in places close to the equator, must be principally ascribed to the *solid* particles in the volcanic ash-cloud, as various observations have shown that these are the main cause of the special absorption of the rays of light by which the sun appeared blue and green; the aqueous vapour may have increased the phenomenon, for it is known that the sun can look bluish through mist. It cannot be said to be a proof to the contrary that Mr. Lockyer saw the sun green through the steam which escaped from the funnel of a steamer, for probably a quantity of ash and soot-particles escaped from the funnel at the same time, and it is possible that the sun appeared green from that very fact. The steam was thus in the identical condition of our volcanic cloud. It was only in the beginning after the eruption, before the ashes had spread very far, and when, therefore, their density was greater, that they were able within a limited space to give green tints to the sun. This phenomenon ceased when the ashes were dispersed further round the globe—in the northern hemisphere by the south-west, in the southern hemisphere by the north-west winds—and when probably also a portion of them fell gradually on the earth.

The crimson after-glows which soon followed the eruption were observed *at the same time* over a much larger area than that within which the blue and green sun was seen at successive periods, and they are believed by Mr. Verbeek to have been caused mainly by the masses of aqueous vapour thrown out by Krakatão, and which formed the greater part of the volcanic cloud. This vapour, after condensing and freezing in the higher and colder regions of the atmosphere, produced the remarkably beautiful sunsets, while the ashes may have intensified the phenomenon, besides serving as a centre of condensation for the vapour. The real cause of the crimson glows was therefore probably the same as that of the evening red, their intensity being a consequence of the extraordinary quantity of vapour in the upper regions emitted by Krakatão.

THE PARIETAL EYE OF HATTERIA

SOME little time ago, whilst engaged in work upon *Hatteria punctata*, I found a curious sense-organ embedded in the substance occupying the parietal foramen, but was unable at the time to examine the specimen further; Prof. Moseley has kindly directed my attention to a short paper published in the *Zoologischer Anzeiger*

[1] Of these, by the bye, only 38·8 per cent. can be utilised for want of fuel, as pointed out by me in my patent of 1871, and verified four years later by the force of Nobel's blasting gelatin, in which the excess of 3·52 per cent. oxygen is utilised by the dissolved gun-cotton, an explosive too rich in carbon. See Abbot's table, p. 17, in "The Hell-Gate Explosion near New York and so-called 'Rackarock,' with a few words on so-called 'Panclastite,'" by H. Sprengel. London: E. and F. N. Spon, 1886.

for March 29, 1886, by Von Henri W. de Graaf, "Zur Anatomie und Entwickelung der Epiphyse bie Amphibien und Reptilien," wherein are described briefly (1) the development of the epiphysis, and (2) the structure of this part in the adult animal in certain amphibia and reptiles. An examination by means of sections at once revealed the fact that in Hatteria the epiphysis becomes modified in a manner more interesting than that found by Von Graaf to obtain in *Anguis fragilis*—the most modified form described by him.

The epiphysis apparently arises as a hollow outgrowth from the roof of the third ventricle (region of thalamencephalon), and in both amphibia and reptilia becomes divided into two parts—a proximal one remaining in connection with the brain, and a distal bladder-shaped structure—the two becoming in most cases completely separated from each other. In *Anguis fragilis* Von Graaf finds that the distal part loses all connection with the brain, and develops into a structure resembling a highly organised invertebrate eye with, however, the important and curious exception that no nerve is present.

In Hatteria a still more interesting modification takes place, the distal portion being, as in Anguis, modified to form an eye; but this, unlike that in the latter, is provided with a well-marked nerve.

Fig. 1 shows the structure of the eye. The whole is enclosed in a capsule of connective tissue (C); anteriorly a lens (L) is present, composed of cells whose nuclei are very distinct. The lens forms the anterior boundary of a vesicle, the walls of which are formed

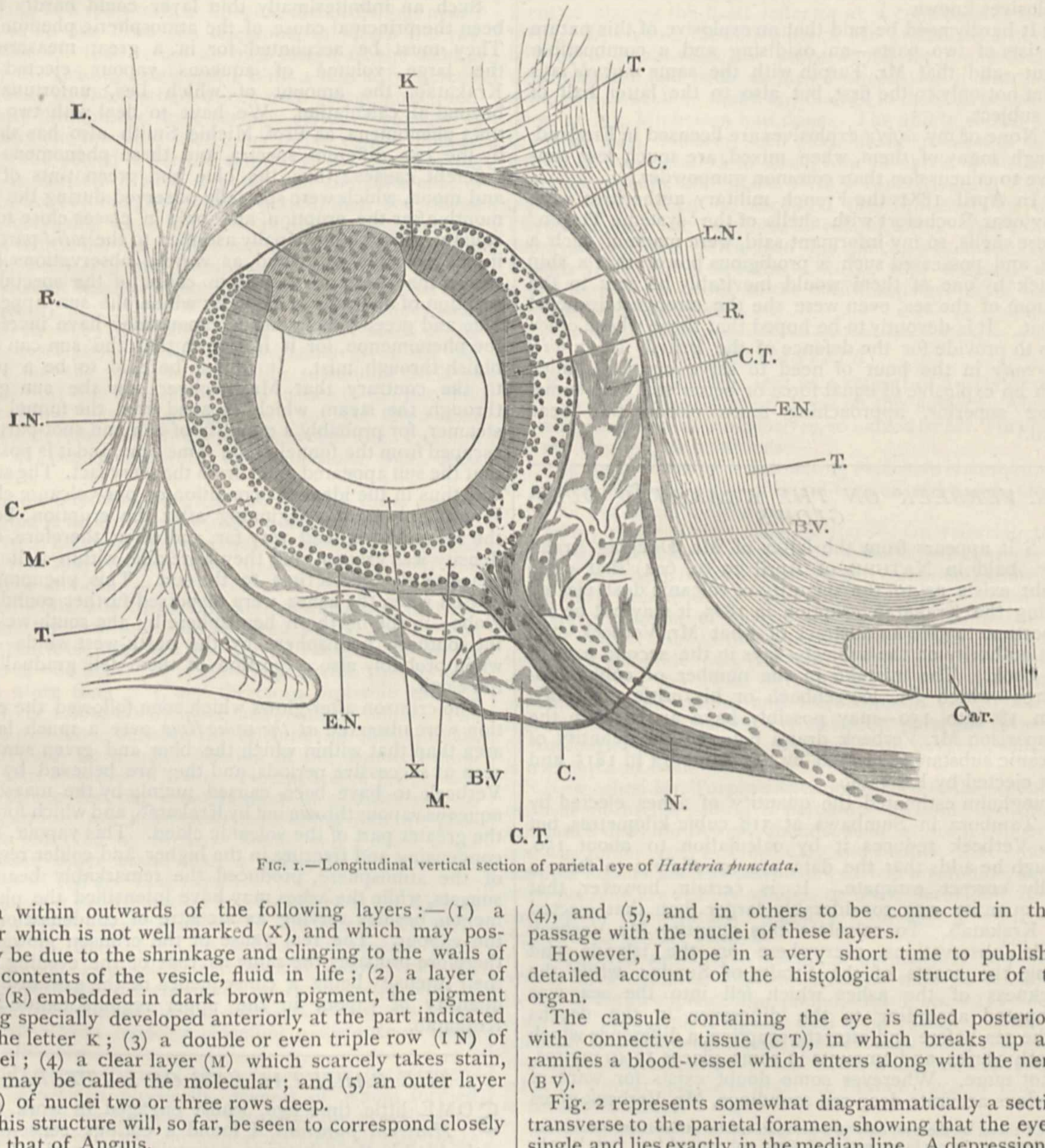

FIG. 1.—Longitudinal vertical section of parietal eye of *Hatteria punctata*.

from within outwards of the following layers:—(1) a layer which is not well marked (X), and which may possibly be due to the shrinkage and clinging to the walls of the contents of the vesicle, fluid in life; (2) a layer of rods (R) embedded in dark brown pigment, the pigment being specially developed anteriorly at the part indicated by the letter K; (3) a double or even triple row (I N) of nuclei; (4) a clear layer (M) which scarcely takes stain, and may be called the molecular; and (5) an outer layer (E N) of nuclei two or three rows deep.

This structure will, so far, be seen to correspond closely with that of Anguis.

Posteriorly a nerve enters the eye, the fibres spreading round behind the vesicle; the rods may be observed giving off processes from their external ends, which in some cases appear to pass right through the layers (3), (4), and (5), and in others to be connected in their passage with the nuclei of these layers.

However, I hope in a very short time to publish a detailed account of the histological structure of the organ.

The capsule containing the eye is filled posteriorly with connective tissue (C T), in which breaks up and ramifies a blood-vessel which enters along with the nerve (B V).

Fig. 2 represents somewhat diagrammatically a section transverse to the parietal foramen, showing that the eye is single and lies exactly in the median line. A depression of the skin of the head occurs immediately over the parietal foramen, but does not lead down into this, which is filled up by a plug of connective tissue (Fig. 1, T, Fig. 2, P T), specially dense (D T) around the eye capsule. The nerve is single, and leads downwards and backwards in the median line, being enveloped in the tissue passing from the foramen directly to the roof of the thalamencephalon.

I have not yet actually traced the nerve itself into the brain, but it is difficult to imagine that it can possibly arise as a branch from a cranial nerve, being *single* and *medianly placed*, and, as just said, enveloped in the material running directly to the roof of the brain from the foramen.

There can be little doubt that it represents the stalk connecting the distal with the proximal outgrowth from the roof of the thalamencephalon, this part having apparently disappeared in other reptiles and amphibia (so far as is yet known).

This being the case it is extremely interesting to observe that another instance will be added to that of the optic nerves in which an, at first, hollow outgrowth from the brain becomes solid and transformed into a nerve, and further that the latter, as in the former case, is connected with an organ of vision.

Though it is difficult to imagine what can be the use of the organ in its present state, seeing it is deeply embedded in connective tissue—so deeply as almost to

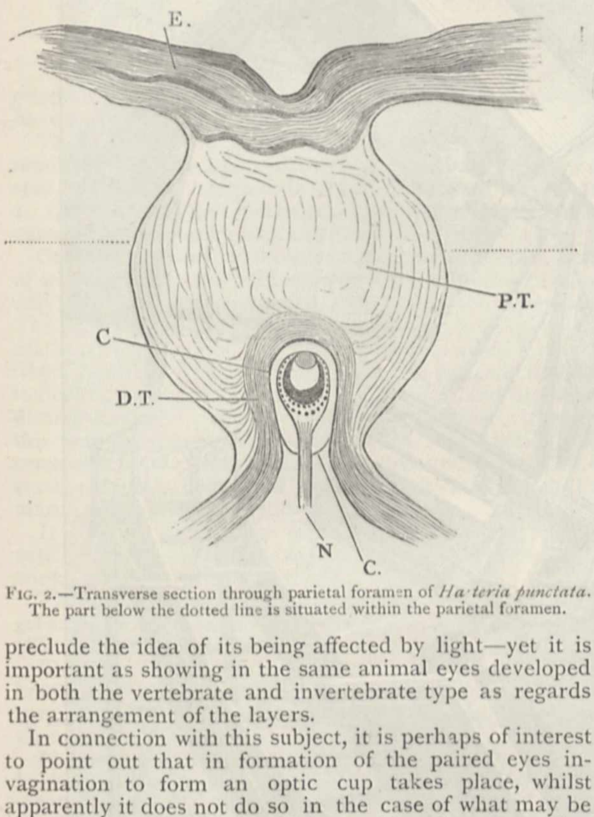

Fig. 2.—Transverse section through parietal foramen of *Hatteria punctata*. The part below the dotted line is situated within the parietal foramen.

preclude the idea of its being affected by light—yet it is important as showing in the same animal eyes developed in both the vertebrate and invertebrate type as regards the arrangement of the layers.

In connection with this subject, it is perhaps of interest to point out that in formation of the paired eyes invagination to form an optic cup takes place, whilst apparently it does not do so in the case of what may be called the *parietal eye*. A little consideration shows that the relative position of the rods depends entirely upon this invagination. In both cases they are formed upon the inner surface of the wall in the position corresponding to the epithelium of the neural canal: but in the one instance they are, by decay of the outer wall of the invaginated cup, placed apparently on the outside of the optic vesicle; whilst in the other instance they are formed in a similar position, but, as no invagination takes place and subsequent decay of one wall, they line the cavity of the vesicle. According to this we must suppose that the part of the wall where the lens is present has either disappeared or become modified into this.

We may further observe that in both types of eye the nerve enters into connection with the elements on the surface opposite to that on which the rods are developed.

In conclusion my thanks are due to Prof. Moseley for his kindness in drawing my attention to the subject, and to Mr. E. B. Poulton, of Keble College, Oxford, who kindly placed two specimens of Hatteria at my disposal, and to Mr. Beddard, of the Zoological Society, for the use of another specimen.

W. Baldwin Spencer

Anatomical Department, University Museum, Oxford

Note.—Since writing the above I have found the eye present in several other lizards, notably in Iguana, *Chameleo vulgaris* and *Lacerta ocellata*, and have traced the nerve into the proximal part of the epiphysis.

ASTRONOMICAL PHOTOGRAPHY[1]

SOME attempts made last year at photographing the heavens by means of an instrument quite rudimentary having yielded good results, the director of the Paris Observatory gave orders for the construction of a special apparatus, the design of which is shown in the accompanying figure (Fig. 1). The mechanical part has been executed in a highly remarkable manner by our accomplished artist, M. Gautier; the objective is our own production.

This new instrument is composed of two telescopes in juxtaposition inclosed in a single metallic tube in the form of a parallelopiped, and separated from each other along their whole length by a narrow partition.

One of the object-glasses, with an aperture of 0·24 m. and a focal length of 3·60 m., is intended for eye observation, and serves as a pointer. The other, with an aperture of 0·34 m. and a focus of 3·43 m., is achromatised for the chemical rays, and serves the purpose of photography. The optical axes of these two objectives being parallel, every star kept in the centre of the field of the eye-piece belonging to the first telescope produces its impression in the centre of the sensitive plate of the photographic apparatus.

The equatorial is mounted in the form called English, that is to say, the centre of the tube rests always in the polar axis of the instrument. This arrangement allows of a star being followed from its rising to its setting without involving the necessity of bringing the instrument back to the vicinity of the meridian. Like a common equatorial it is furnished with hour circle and circle of declination, and with a clock movement keeping the apparatus in operation for three hours without fresh remounting. There are, moreover, independent very slow movements, whereby the axis of the telescope can be kept on a fixed point in the heavens, notwithstanding some slight irregularity in the movement of the clockwork, the orientation of the telescope, or the variations of atmospheric refraction.

The photographic objective—the largest ever yet produced—is formed according to a simple achromatic system, and, though of an extremely short focal length, is able, without the use of any diaphragm, exactly to cover the very considerable field of 3° diameter.

Although but very recently mounted, this apparatus has already availed for the performance of numerous tasks. On star photographs it is possible to distinguish traces of stars of the 15th magnitude, too feebly marked, however, to bear transference on paper. The stars of the 14th magnitude are reproduced with a diameter of 1/40 of a millimetre.

It is obvious that such small points might be liable to be confounded with the impurities of the sensitive coating if the precaution is not taken to multiply the stationary points. Each star is formed by a group of three points constituting an equilateral triangle, each side of which is no more than 1/12 of a millimetre. To the naked eye these three points appear to merge into one, but on examining them with the aid of a somewhat

[1] From an article by the Brothers Henry in *La Nature*.

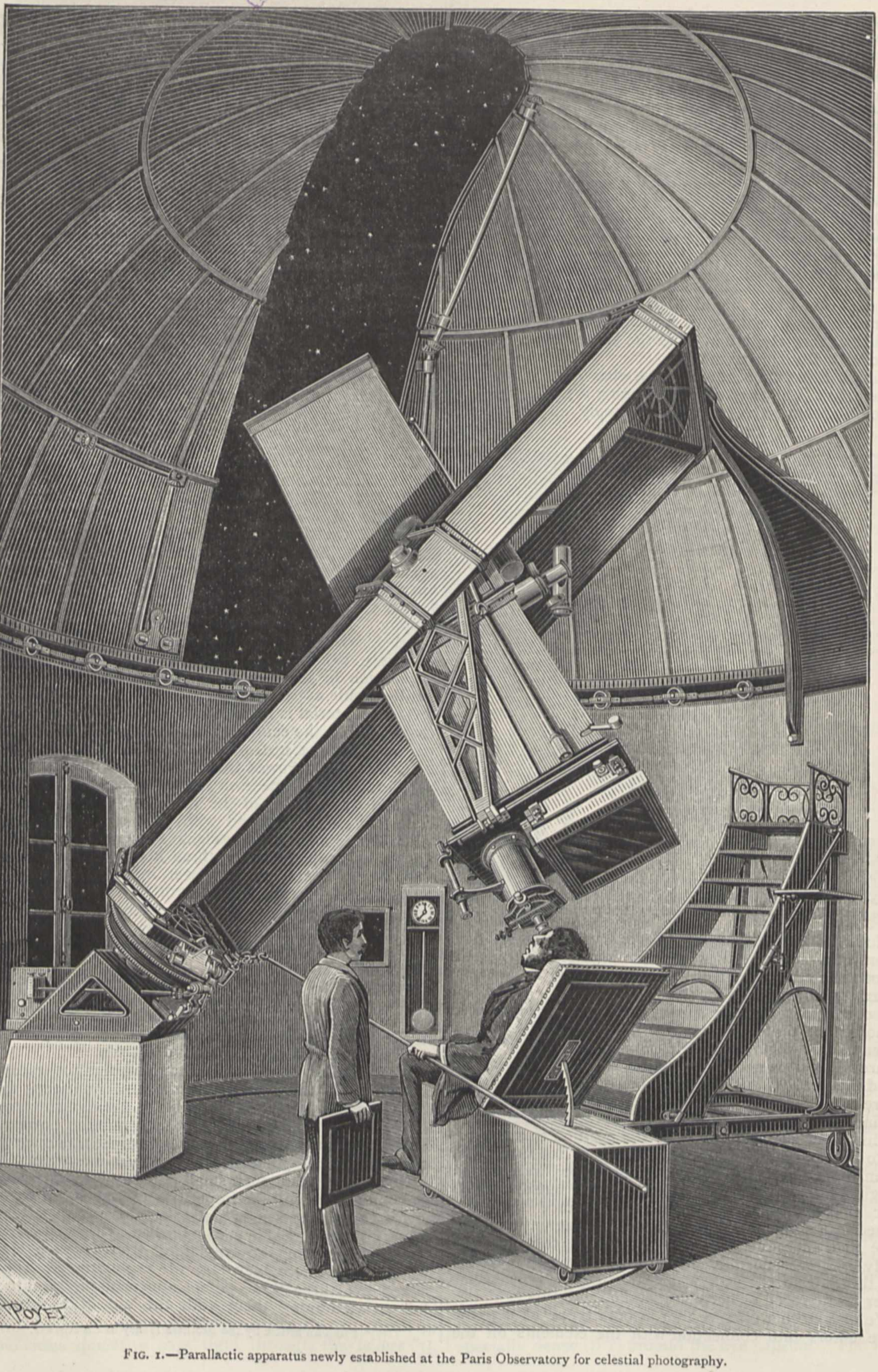

FIG. 1.—Parallactic apparatus newly established at the Paris Observatory for celestial photography.

powerful lens the three points come out distinctly, and it is then an easy task to eliminate all that does not belong to the heavens.

The construction of such a map, obtained by the apparatus as above described in three hours, would assuredly have demanded several months of assiduous labour by the ordinary processes.

The following is the time of exposure requisite to obtain the image of the stars.[1]

Magnitude		h.	m.	s.
1	... ...	0	0	0·005
2	... ...	0	0	0·013
3	... ...	0	0	0·03
4	... ...	0	0	0·08
5	... ...	0	0	0·2
6	The extreme limit of magnitude of stars visible to the naked eye	0	0	0·5
7	... ...	0	0	1·3
8	... ...	0	0	3
9	... ...	0	0	8
10	... ...	0	0	20
11	Mean magnitude of the asteroids	0	0	50
12	... ...	0	2	0
13	... ...	0	5	0
14	... ...	0	13	0
15, 16	The last of the stars visible with the aid of the great instruments	1	23	0

All the above figures represent a minimum. To secure good reproductions on paper the time of exposure would have to be increased threefold.

The above table shows that the time of exposure required in taking a star of the first, and that in taking a star of the last magnitude differ from each other as 1 : 1,000,000. (The relation adopted between the brightnesses of two consecutive magnitudes is 2·542.)

Outside the construction of celestial maps, another field of study of great importance now created by photography may be cited, the discovery, namely, of the asteroids. The little stars fixing themselves on the plate as so many mathematical points, so to say, the planets are distinguished therefrom, each by a little line perfectly defined indicating its proper movement in amount and direction during the time of exposure of the apparatus. It is in this way we have already succeeded in obtaining the trace of a small planet of the 11th magnitude which by a small line extremely well defined gave account of its march among the fixed stars.

It will even be possible to study the movement of the satellites round their planet, and perhaps discover new ones.

The study of the double and multiple stars will be greatly facilitated, and photography will be equally available in the investigation of the parallaxes.

Finally, photometry must be adduced as one of the branches of astronomy which will now be able to collect very valuable information through the utilisation of photography.

In conclusion, it is worth while remarking how this fresh step in advance has sensibly enlarged the scope of man's vision. In consequence of it we can now obtain the image of a star, which instruments of the same opening as those employed by photography would never of themselves have elicited out of their invisibility.

PAUL ET PROSPER HENRY

NOTES

THE first *soirée* of the Royal Society this season took place last night. A large number of Fellows and visitors were present, and many objects of interest were exhibited.

THE visitation of the Royal Observatory by the Board of Visitors is fixed this year for June 5.

[1] For these results we have made use of the gelatino-bromide plates of Monckhoven.

THE Royal Irish Academy is celebrating the centenary of its foundation this week.

DR. GILL, Her Majesty's Astronomer at the Cape, has been elected Corresponding Member of the Imperial Academy of Sciences of St. Petersburg.

THE fifty-seventh anniversary meeting of the Zoological Society was held on Thursday week. The chair was taken by Prof. Flower, LL.D., F.R.S., the President. The report of the Council on the proceedings of the Society during the year was read by Mr. P. L. Sclater, F.R.S., Secretary of the Society. It stated that the number of Fellows on December 31, 1885, was 3193, showing a decrease of 62 as compared with the corresponding period in 1884. The total receipts for 1885 had amounted to 25,809*l.* 10*s.* 1*d.*, being a decrease of 3129*l.* as compared with the previous year. This decrease was mainly due to the falling off in the receipts under the head of admissions to Gardens, and in the amounts received for admission and composition fees from newly elected Fellows. The ordinary expenditure for 1885 had been 24,593*l.* 11*s.* 8*d.*, against 26,539*l.* 4*s.* 1*d.* for 1884. Besides that, an extraordinary expenditure of 491*l.* 0*s.* 6*d.* had been incurred, which brought up the total expenditure for the year to 25,084*l.* 12*s.* 2*d.* The visitors to the Society's Gardens during the year 1885 had been 659,896, against 745,460 in 1884. The Davis Lectures on zoological subjects, having been well attended during the past year, would be continued during the present season, beginning with a lecture on "Pigs and their Allies," by Prof. Flower, LL.D., F.R.S., on Thursday, June 3, at 5 p.m. The number of animals in the Society's collection on December 31 last was 2551, of which 756 were mammals, 1366 birds, and 429 reptiles. Among the additions made during the past year 21 were specially commented upon as of remarkable interest, and in most cases new to the Society's collection. About 36 species of mammals, 15 of birds, and 4 of reptiles had bred in the Society's Gardens during the summer of 1885. The report concluded with a long list of the donors and their various donations to the menagerie during the past year.

WITH regard to the recent explosion of the 43-ton gun, it is fortunate that it has happened without loss of life. Competent authorities, as seen from Col. A. Moncrieff's letter (which we reproduce from the *Times*) show that it could. How long are our gun factories to go on making guns condemned by easily-understood scientific principles? "Col. Maitland's interesting paper read at the Royal United Service Institution on June 20, 1884," Col. Moncrieff writes, "published the process adopted at Woolwich in settling the types of the new steel breech-loading ordnance for the British service, as well as the proportions of the new guns on these types then in process of manufacture. Mr. W. Anderson's investigations, published in a lecture read before the Society of Arts on January 29, 1885, and also commented upon in the *Engineer* of February 6, 1885, clearly demonstrated that these guns were deficient in strength in front of the trunnions. It is a remarkable fact that several of the guns have now burst at the point and in the manner which could have been predicted by any one consulting Mr. Anderson's demonstrated results. As the subject is of vital importance to the country, it would seem wise either to refute Mr. Anderson or accept his method and consult him; his valuable service in having discovered the prevailing error and worked out this most difficult problem is too little known; it would thus be utilised and acknowledged to the advantage of the service. By treating a gun as a heat-engine and accounting for every part of the energy generated by the explosion of the powder, he has, in a scientific and complete manner, proved that the metal crusher gauges from which the accepted curve of pressure is obtained are not to be relied on.

The form of the guns is adapted to the curve of pressure; that curve, as shown by Col. Maitland at the Royal United Service Institution, is wrong; the maximum pressure which is near the breech is known, but with the slow-burning powder in a long gun the total pressure, and the maximum pressure at any point of the bore, has never been accurately determined. If Mr. Anderson's conclusions carefully arrived at by calculation are correct, these guns are out of proportion between the trunnions and the muzzle, where the bursts have all taken place. Another branch of the same subject is the measurement of the energy of recoil, of much importance in designing disappearing carriages. In this branch, I can answer for it, that Mr. Anderson's conclusions tally with the practical result—a satisfactory proof of their correctness. His discovery is of great practical value in making gun-carriages of all descriptions, and has changed, once and for all, the previously accepted formulæ for the force of recoil given in the text-books, which often led to costly mistakes in construction. Mr. Anderson has been trying, since the publication of his lecture at the Society of Arts, to induce the Government to test the correctness of his views by means of the Sebert velocimeter, but without success. It must be admitted that in determining so important a matter, one on which the efficiency of our ships and a large national expenditure depends, it should be the first desire of every one to secure without delay the highest scientific and practical experience within reach, and to consult men who have devoted special study and research to the subject."

ON April 30 there took place in Paris, at the Ministry of Public Instruction, a meeting of French astronomers. M. Faye was in the chair. It was decided unanimously to build three photographing telescopes. One of these is destined for the Algiers Observatory. The destination of the others will be determined upon when finished. The construction will take eighteen months.

M. JANSSEN has terminated the installation of the tubes for analysing the influence of the atmosphere on spectroscopic analysis, absorbing power, &c. Their length is 100 metres, and they can be filled with gas under a pressure of 100 atmospheres. The light is supplied by a battery of 60 Bunsen elements. Experiments are conducted on nitrogen, oxygen, common air, &c.

HERR PAUL VON RITTER, who died at Basle, has left to the University of Jena a sum of 300,000 marks, to be employed for the furtherance of zoological studies.

CANADA is nearly the only important British colony without its Government Botanic Garden; the identity of its flora with that of the Northern United States rendering such an establishment of much less value than in most of our colonial possessions. But for some years past leading Canadians interested in horticulture have been exerting themselves for the establishment of a Botanic Garden at Montreal. Through the co-operation of the authorities of McGill College and the Council of the Montreal Horticultural Society, this object is now secured, and the "First Annual Report" of the "Montreal Botanic Garden" is issued. The Garden is not yet in existence; but a very favourable site of seventy-five acres has been secured in Mount Royal Park, a varied piece of ground admirably adapted for the purpose, on the slope of the beautiful mountain overlooking the city, from which it derives its name. An Act of Incorporation for the "Montreal Botanic Garden Association" has been obtained, wherein the objects of the corporation are stated to be "By the medium of a Botanic Garden and other accessories, to promote research in forestry and economic botany, and advance the interests of technical and general botanical knowledge." Among the means contemplated in the future for carrying out these objects we are glad to see the establishment of courses of lectures on special subjects and a laboratory for special research. We wish every success to the new Association, which solicits contributions in trees, shrubs, seeds, and publications.

AT the last general meeting of the Folk-Lore Society, Capt. Temple read a paper on the science of folk-lore. At the conclusion he referred to terminology. Folk-lore, he said, is a fine English compound, but there is a sad want of an alternative, if only for the sake of useful and necessary derivatives. Folklorist and folk-loric are not pleasant forms, but students have been driven to use both. He suggests some classically-formed synonym, such as *demology*, *demosophy*, or *demonocy*—the last for choice—capable of easy development into passable derivatives, as being of practical use. Dogma has been appropriated already, or *dogmology* might, he thinks, answer, and *demodogmology* is too long. *Dokeology* and *dokesiology*, as the study of fanciful opinions, are also suggested.

IN a recent article in *La Nature* M. Martel refers to a discovery which he has made in the prehistoric caves in Lozère. For fifteen years past Dr. Prunières has prosecuted his investigations into the dolmens and neolithic grottos of the gorges of the Tarn, and has obtained some curious results on the fusion of a race of the age of polished stones and of an invading race of the Bronze Age. Last year in the cave of Nabrigas, M. Martel found in immediate contact with the remains of at least two skeletons of the *Ursus spelæus*, or great Quaternary bear, nine fragments of human skulls, of which one left superior maxillary had three teeth, and a piece of rough pottery, not turned in a lathe. The question whether, in the Stone Age, man, the contemporary of the reindeer and the great bear, was acquainted with the use of pottery is much debated, eminent names being found supporting the negative as well as the positive. But (continues M. Martel) the curious point about the present find is that fifty years ago, before the birth of "prehistory," when the existence of even Quaternary man was contested, M. Joly found in this very cave of Nabrigas a fragment of a large vessel in contact with the skull of a fossil bear. M. Martel is strongly of opinion that the usual theory of the fortuitous contact of these objects does not apply here; there is no trace of any disturbance, nor are any other neolithic objects found, the skull is in its natural position,—for these and other reasons he is persuaded that fossil man of the palæolithic age was acquainted with the potter's art.

THE fish-hatching season at South Kensington, accounts of which we have published from time to time, is now drawing to a close, although there are still half a million fry on view at the Exhibition which have not yet absorbed their *umbilical sac*. The various species of fish bred have been presented by the National Fish Culture Association to public waters in the vicinity of London and in the country, whilst the Fishery of the Association has been well stocked with fry.

THE Thames Angling Preservation Society, which is ever ready to secure fresh supplies of fish for the Thames, have lately netted one of the ponds in Kew Gardens for this purpose.

DURING the present week large consignments of fish have arrived at the aquarium of the Colonial and Indian Exhibition from the south coast and North Sea. The latest arrivals consist of cod, lings, haddocks, crustaceans of various species, grey mullet, bream, and Salmonidæ. A large Ascension turtle has also arrived in the tropical department, measuring 4½ feet by 3 feet. Considering the protracted period it was out of the water during transit, its condition on being placed in the Chelonian tank did not evidence the slightest signs of diminished vitality, which is another proof of the hardihood and tenacity of life possessed by this species. The turtle tank now contains twenty large specimens of the green and hawksbill kind, all of which seem in good health notwithstanding the artificial existence to which they are subjected. In contiguity to the tank is a miniature beach whereon the turtle rest when out of water. A consignment of turtle eggs is expected this week, which will be laid out in the hatchery on arrival for the purpose of incubation. Some West Indian tortoises have just arrived, together with a selection of snakes and lizards, which form interesting exhibits. In consequence of the inability of the Royal Commissioners to obtain Indian and Colonial fishes, the National Fish Culture Association have taken the matter into their own hands, and have made arrangements with the Zoological Society in Calcutta and other bodies for supplies of tropical and other piscatorial specimens, so that the aquarium will be supplemented with many rare and important specimens.

MR. OTIS T. MASON's account of the valuable Guesne collection of antiquities in Point-à-Pitre, Guadaloupe, which appeared in the Smithsonian Report for 1884, has recently been issued in separate form. The collection originated with M. Mathieu Guesne, whose series of Carib stone implements attracted considerable attention at the Paris Exhibition of 1867. Since then it has been continued, and all but completed, by the son, M. Louis Guesne, who has devoted nearly twenty years of assiduous labour to the task of rescuing from destruction all existing relics of the ancient Carib race in the Island of Guadaloupe. He has also applied his artistic skill to the illustration of these objects, filling two large albums with aquarelles in natural size and colour of all the types in his museum. From these sources Mr. Mason has mainly compiled the present account, which is enriched with no less than 215 carefully prepared woodcuts of the Point-à-Pitre collection, and of a few others introduced for the purpose of comparison, and to supply omissions in West Indian archæology. The collection includes roughly-worked stones, indicating an industry in its infancy; and others so perfectly finished that it would be difficult to improve upon them either in design or workmanship. But all alike belong to what would be called the Neolithic period in Europe; all the stone implements are polished, and there is not a single object of this class formed solely by being chipped. In fact, the volcanic materials of which they are made cannot be worked by chipping, like flint, quartz, or obsidian. Some, especially, of the axes are so small that they seem to belong to a race of pigmies, while others are so large and heavy that they suggest a generation of Titans rather than of human beings. Besides the movable objects, mention is made of enormous stones carved with strange designs resembling those described by Mr. Im Thurn in British Guiana, some so high up as to be almost out of reach, others close to the ground or buried under the surface. Similar inscribed stones occur in the beds of rivers in the Island of St. Vincent, the last refuge of the Caribs in the West Indies.

HERR SCHÖYEN, in a paper recently reprinted from the *Transactions* of the Scientific Society of Christiania, describes a form of disease affecting the roots of growing barley, through which the farmers in Norway have of late years been suffering extensive loss. Contrary to the common opinion that the ravages due to this blight—which is popularly known as "Krog," crook, from the form of the deposits—were produced by an insect, Herr Schöyen maintains that this special barley-pest is a microscopic round worm, of the genus Tylenchus. After describing the appearance and character of the parasitic germs, which are deposited at the extremities of the roots, where their presence speedily manifests itself by the withering and death of the stalk before the grain can be set, he draws attention to the fact that similar deposits have been noticed on the roots of *Elymus arenaria*, the bind-grass so frequent on the Scotch, as well as the Norwegian, coasts. This observation derives special practical importance from the circumstance that at Lom, in Norway, where the barley crops have suffered most severely from the "Krog," the affected fields are in close vicinity to extensive tracts of *Elymus arenaria*. He proposes to continue his observations next summer with special reference to this point, but in the meanwhile he recommends as the only remedy available for the present that barley should not be re-sown on ground where the disease had manifested itself in the preceding season, nor in any locality where Elymus abounds. He finds that the bladder-like egg-cases of *Tylenchus hordei* can be thoroughly desiccated without destroying the inclosed worms.

SOME interesting statistics of the Japanese press have lately been published in the *Oesterreichische Monatsschrift für den Orient*, in which the newspapers and periodicals of Japan are arranged according to the subjects with which they deal. It appears that 37 publications are devoted to matters connected with education, and that these have a total circulation of 42,649 per month. There are 7 medical papers, with a monthly circulation of 13,514; 9 relating to sanitary matters, with a circulation of 8195; 2 on forestry; and 2 on pharmacy. There are 7 devoted to various branches of science, with a circulation of 2528; but to these must be added 29 engaged in popularising science, with a total circulation of 70,666.

THE additions to the Zoological Society's Gardens during the past week include a Purple-faced Monkey (*Semnopithecus leucoprymnus* ♀) from Ceylon, presented by Mrs. Larkins; a Brazilian Tree Porcupine (*Sphingurus prehensilis*) from Brazil, presented by Mr. J. E. Wolfe; two Sloth Bears (*Melursus ursinus* ♂ ♀) from India, presented by Mr. H. Mainwaring; a Burmese Squirrel (*Sciurus atrodorsalis*) from Burmah, presented by Mr. C. Crofton Black; a West Indian Agouti (*Dasyprocta cristata*) from West Indies, presented by Dr. A. Boon, F.R.C.S.; an Orange-thighed Falcon (*Falco fusco-cærulescens*) from Chili, presented by Capt. W. M. F. Castle, R.N.; five Senegal Parrots (*Pæocephalus senegalus*) from West Africa, presented by Mr. R. B. Sheridan; two Kestrels (*Tinnunculus alaudarius*), British, presented by Mr. J. S. Malcolm; a Wedge-tailed Eagle (*Aquila audax*) from Australia, presented by Mr. R. B. Colvin; a Tuberculated Iguana (*Iguana tuberculata*) from West Indies, presented by Mr. D. Morris; seven European Tree Frogs (*Hyla arborea*), European, presented by Mr. Thompson Hudson; a Californian Quail (*Callipepla californica*) from California, a Herring Gull (*Larus argentatus*), British, presented by Miss Hodge; a Two-banded Monitor (*Varanus salvator*), two Rat Snakes (*Ptyas mucosa*), an Indian Cobra (*Naia tripudians*) from Ceylon, presented by Mr. Carl Hagenbeck; a Moorish Toad (*Bufo mauritanica*) from Italy, a Green Toad (*Bufo viridis*) from Malta, presented by Mr. Alban Doran, F.R.C.S.; two Greek Tortoises (*Testudo græca*), European, presented by Admiral Mellersh; two Common Vipers (*Vipera berus*), British, presented by Mrs. Mowatt; a Small Hill-Mynah (*Gracula religiosa*), from Southern India, deposited; a Hog Deer (*Cervus porcinus*), seven Long-fronted Gerbilles (*Gerbillus longifrons*), born in the Gardens.

OUR ASTRONOMICAL COLUMN

THE FLEXURE OF MERIDIAN INSTRUMENTS.—In a paper which forms Appendix III. to the "Washington Observations" for 1882, Prof. Harkness has made an exhaustive discussion of the subject of flexure, and the means available for eliminating its effects from star-places. He discusses separately the flexure of transit instruments and of vertical circles. The former are divided into two classes, according as their telescopes are straight or bent, but it is in the latter form that the effects of flexure are by far the greatest, the flexure-coefficients being in some instances as much as 0·55s. Prof. Harkness shows that the effect of flexure cannot be satisfactorily eliminated from the concluded right ascension of a star by simply taking the mean of the four results obtained by observing it directly and by reflection with the clamp of the instrument both west and east. It is better in his opinion to determine for each instrument the necessary corrections to be applied by means of the methods and formulæ explained in this paper.

In discussing the flexure of vertical circles Prof. Harkness compares Repsold's method of eliminating the flexure, by interchanging the object and eye-end of the telescope, with Bessel's method of attaining the same result by observing a star both directly and by reflection with the clamp successively west and east, demonstrating the superiority of the latter method, which appears to be the most satisfactory procedure hitherto devised for freeing an observed declination from the effect of flexure.

Prof. Harkness shows that when there are terms in the flexure depending on multiples of the zenith distance, they cannot in general be completely eliminated, and therefore that star-places derived from observations made with a single instrument are likely to be affected by systematic errors, which will appear when the work of different instruments is compared together. The detection and elimination of such errors can probably, Prof. Harkness thinks, be greatly facilitated by the use of equal altitude instruments of the zenith telescope class, which are so remarkably free from systematic errors.

THE SPECTRUM OF FABRY'S COMET.—M. Trépied having frequently observed the spectrum of this comet since April 7, gives (*Comptes rendus*, vol. cii., No. 18) the following account of it. The three usual cometary bands were seen, and as the brightness of the spectrum allowed a fairly narrow slit, 0·2 mm., to be used, the coincidence of these bands with those of the hydrocarbon spectrum could be very satisfactorily verified. Besides these bands there was also a continuous spectrum, but the remarkable feature of the case was that although the nucleus, which was very distinct and of a truly stellar appearance, appeared very bright as compared with the neighbouring portions of the coma, the band spectrum given by these latter and by the tail was much more brilliant than the continuous spectrum of the nucleus. This circumstance, which was also observed by MM. Thollon and Perrotin at Nice, had been remarked by M. Trépied in Encke's comet last year. He is therefore led to conclude that there is a predominance of gaseous elements in both these comets, and that, further, the relative brilliance of the nucleus of a comet is not necessarily in accord with the degree of condensation of the cometary matter.

On April 14 the bright bands could be easily detected in the spectrum of the tail to a distance of 20′ from the nucleus. The total length of the tail was then more than 3°.

TWO NEW COMETS.—Mr. W. H. Brooks, Red House Observatory, Phelps, New York, discovered two new comets in the last week of April, the first on April 27, the second on April 30. The former is described by M. Bigourdan as being on May 1 a round nebulous object, about 2′ in diameter, brighter towards the centre, but without a nucleus. The existence of a very faint nucleus was, however, suspected on the following night. On May 6 Lieut.-Col. Tupman estimated the comet as being of the 8th magnitude. Dr. H. Kreutz has computed the following elements and ephemeris for it:—

$$T = 1886 \text{ June } 6{\cdot}9585 \text{ Berlin M.T.}$$

$$\left.\begin{aligned}\omega &= 202^\circ\ 55'{\cdot}68\\ \Omega &= 191\ 48{\cdot}58\\ i &= 87\ 33{\cdot}03\end{aligned}\right\}\ \text{Mean Eq. } 1886{\cdot}0$$
$$\log q = 9{\cdot}40752$$

Ephemeris for Berlin Midnight

1886	R.A. h. m. s.	Decl. ° ′	Log Δ	Brightness
May 13	2 9 38	51 43·7 N.	0·1062	2·2
17	2 30 25	47 52·2	0996	2·9
21	2 49 32	43 25·9	0931	4·1
25	3 7 48	38 17·2	0865	6·2
29	3 26 26	32 15·3 N.	0·0794	10·0

The brightness on April 29 is taken as unity.

The second comet is described (*Astr. Nach.* No. 2728) by the Baron von Engelhardt as being very bright on May 3, although the evening was misty. The comet was visible in a bright field, and showed a circular nucleus, from whence proceeded a brighter offshoot, 2′ in length, in the direction of the axis of the tail. The tail was 8′ in length and very bright, narrow at first, but broadening by degrees, and curved with the convex side towards the north. A secondary tail, 6′ in length, faint, and bending towards the south, forked off from the principal tail about 6′ from the nucleus. The following elements and ephemeris are by Dr. E. Lamp:—

$$T = 1886 \text{ May } 4{\cdot}13040 \text{ Berlin M.T.}$$

$$\left.\begin{aligned}\omega &= 37^\circ\ 50'{\cdot}15\\ \Omega &= 287\ 22{\cdot}88\\ i &= 99\ 47{\cdot}53\end{aligned}\right\}\ \text{Mean Eq. } 1886{\cdot}0.$$
$$\log q = 9{\cdot}92518$$

Error of middle place $(O - C)$.

$$d\lambda = +\,0'{\cdot}19 \qquad d\beta = -\,0'{\cdot}02$$

Ephemeris for Berlin Midnight

1886	R.A. h. m. s.	Decl. ° ′	Log *r*	Log Δ	Brightness
May 12	23 52 46	47 23·0 N.	9·9326	9·9924	1·0
14	0 5 38	51 23·8	9·9364	9·9980	0·9
16	0 20 38	55 10·5	9·9410	0·0056	0·9
18	0 38 9	58 39·8	9·9462	0·0149	0·8
20	0 58 38	61 49·5	9·9520	0·0255	0·8
22	1 22 15	64 35·6	9·9583	0·0373	0·7
24	1 49 21	66 55·8	9·9652	0·0501	0·6
26	2 19 47	68 48·4	9·9725	0·0636	0·5
28	2 52 55	70 11·7	9·9802	0·0775	0·5
30	3 27 37	71 5·8 N.	9 9881	0·0918	0·4

The brightness on April 30 is taken as unity.

NEW MINOR PLANET.—A new minor planet, No. 258, was discovered on May 4 by Dr. Luther at Dusseldorf, R.A. 15h. 20m., Decl. 9° 31′ S.; daily motion, R.A. − 48s., Decl. + 7′; mag. 11.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1886 *MAY* 16-22

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on May 16

Sun rises, 4h. 8m.; souths, 11h. 56m. 9·3s.; sets, 19h. 44m.; decl. on meridian, 19° 9′ N.: Sidereal Time at Sunset, 11h. 22m.

Moon (Full on May 18) rises, 17h. 51m.; souths, 23h. 5m.; sets, 4h. 10m.*; decl. on meridian, 11° 22′ S.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury	3 34	10 24	17 14	9 7 N.
Venus	2 48	9 4	15 20	2 29 N.
Mars	12 23	19 13	2 3*	8 57 N.
Jupiter	13 52	20 10	2 28*	2 53 N.
Saturn	6 37	14 49	23 1	22 49 N.

* Indicates that the setting is that of the following morning.

Occultations of Stars by the Moon (visible at Greenwich)

May	Star	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image ° °
17	η Libræ	6	22 16	23 32	64 240
19	24 Scorpii	5	0 37	near approach	167 —
21	*d* Sagittarii	5	22 1	22 57	19 266
22	B.A.C. 6658	6	5 2	near approach	206 —

Variable Stars

Star	R.A. h. m.	Decl. ° ′		h. m.	
ζ Geminorum	6 57·4	20 44 N.	May 20,	2 20	*m*
V Virginis	13 21·9	2 35 S.	„ 17,		*M*
δ Libræ	14 54·9	8 4 S.	„ 16,	2 8	*m*
U Ophiuchi	17 10·8	1 20 N.	„ 16,	0 44	*m*
			„ 21,	1 30	*m*
X Sagittarii	17 40·4	27 47 S.	„ 19,	2 25	*m*
			„ 22,	0 0	*M*
W Sagittarii	17 57·8	29 35 S.	„ 21,	21 40	*M*
β Lyræ	18 45·9	33 14 N.	„ 16,	0 0	*m*
S Vulpeculæ	19 43·7	27 0 N.	„ 17,		*m*
η Aquilæ	19 46·7	0 7 N.	„ 19,	0 0	*m*
δ Cephei	22 24·9	57 50 N.	„ 20,	21 35	*m*

M signifies maximum; *m* minimum.

Positions of the Comet Barnard (for Berlin Midnight)

May	R.A. h. m. s.	Decl. ° ′	Log. Δ	Brightness
16 ...	2 20 49 ...	28 0 N. ...	9·682 ...	284
18 ...	2 35 41 ...	23 17 ...	9·637 ...	318
20 ...	2 53 8 ...	17 23 ...	9·596 ...	349

GEOGRAPHICAL NOTES

AMONGST the members of the mission proceeding from India to Tibet, under the charge of Mr. Colman Macaulay, are Col. Tanner, surveyor, Dr. Oldham, geologist, and Dr. Cunningham, naturalist. The expedition will leave Darjeeling about the end of the present month, and, marching through independent Sikkim, will cross the Jalepla Pass into Tibet. Its destination is Lhassa, the capital. Once only has this city been visited by an Englishman, Thomas Manning, and practically the whole route lies through a *terra incognita*. As Mr. Macaulay bears letters from the Chinese authorities, for which he made a special journey to Pekin last year, it is not anticipated that he will meet with any obstacles on his way to, or during his stay on, "the roof of the world." The three scientific members of his mission will find abundance of work to do, and the news of the progress of the expedition may be looked for with interest.

THE new number of the *Journal* of the Royal Asiatic Society (vol. xviii., part 2) contains an interesting article by Mr. Morison, of Tiflis, on the geographical distribution of Turki languages. The following is a summary. Dividing Turki into five sub-branches—Turki proper, Nogai, Uigur, Khirghiz, and Yakut—he states that the various subdivisions of, first, Turki proper, are spoken by the ruling class of the Ottoman Empire and the inhabitants of Asia Minor, in the Governments of Nijni Novgorod, Kasan, Simbirsk, Viatka, and Orenburg, in Trans-Caucasia, and North-Western Persia; the Nogai in Bessarabia, the Crimea, Cis-Caucasia, the Volga Delta, North-Eastern Daghestan, Terek Valley, the north-western shore of the Caspian, the Governments of Kasan and Simbirsk, Astrakan, Orenburg, and Ufa; the Uigur in Yarkhand and Chinese Tartary, the country of the Tekke, Zarafshan Valley, and generally in Central Turkestan, in the Khanate and Desert of Khiva and south of the Aral Sea, and in Kuldja; the Kirghiz from the Volga to the confines of Manchuria, but most compact in South-Western Siberia; and the Yakut in North-Eastern Siberia and on the northern slopes of Mount Sayan. Broadly speaking, says Mr. Morison, the Ugro-Altaic languages, of which Turki is one, are spoken over a region extending through more than 100° of longitude, from the shores of the Adriatic to the Great Wall of China and the plateau of Tibet, and through 35° of latitude, from the frozen steppes of Samoyede and Yakut to the plains of Northern Persia and the head-waters of the Indus. The Turki alone, according to the figures given, is spoken, in one or other of its various forms, by more than 20,000,000 of people.

THE *Proceedings* of the Royal Geographical Society for May contains a paper by Mr. Carles on his recent journeys in Corea, accompanied by a very useful map of the peninsula. Some account of these journeys has already appeared in Parliamentary Blue-Books, but much is added in the present paper. The writer refers to the many different types found amongst the Coreans of the present day; the facial characteristics of the people greatly resemble those of the Manchus, but Jews, Japanese, and Caucasians appear to be universally represented. There is also a curious reference to evidence of some forms of religion other than those imported from China in the *miriok*, or half-length human figures carved in stone. Mr. Needham also contributes an account of an excursion to the Abor Hills from Sadiya in Upper Assam.

BARON MIKLUHO-MACLAY has just returned to Odessa from his journey to New Guinea, which has lasted two years. He has brought a large collection of rare fishes, lizards, snakes, insects, and so on, packed in twenty-two boxes.

ANOTHER Russian traveller, M. Goudatti, the Secretary of the Moscow Society of Friends of Natural Science, who has also just returned from his journey to the north of Siberia, gives a curious account of his failure to accomplish his purpose. The Ostiaks and Samoyedes took him for a Government official on a recruiting mission, especially when he attempted to measure their heads, and took notes in his note-book. Finally the book was stolen, and all the results of his efforts lost.

HERR RADDE, who had started in January last with a scientific expedition from Tiflis to the Transcaspian region, writes from Askabad lately that this spring was very unfavourable for his researches, being three to four months later than usual. Therefore up to the middle of April he had not succeeded in collecting more than 35 species of plants and about 150 birds. Amongst these latter there is an interesting novelty, the *Picus sindiacus*, a pretty bird living in the high shrubs of *Tamarix*. The explorer intends to proceed during the present month to the mountain region between the Murghab and Tejen, and to return to Askabad through Sarakhs.

THE May number of the *Scottish Geographical Magazine* has an interesting article by Mr. Tripp on the physical configuration and rainfall of South Africa, with notes on its geology, diamond and coal-fields, and forests. The paper is accompanied by two maps showing contours and mean annual rainfall. A note by M. Dingelstedt on geographical education in the schools of the Caucasus shows that in Russia primary instruction in geography is as defective as in England. It is not made attractive, the writer complains; it only taxes the memory; the text-books are written to match, and few teachers are equal to the task of interesting their pupils in the subject. There are some interesting notes on the place-names of Kinross-shire by Mr. Liddall, and on the seaboard of Aberdeenshire, by Mr. Ferguson. The geographical notes are particularly copious and comprehensive.

THE current number (Bd. xiii. No. 4) of the *Verhandlungen* of the Berlin Geographical Society contains only one paper—a lecture by Dr. Naumann on the Japanese Islands and their inhabitants. The *Zeitschrift* of the same Society (Bd. xxi. Heft 2) is mainly occupied by a paper of Dr. Schweinfurth's on a journey which he made in the "region of depression" around Fayoum at the commencement of the present year. It is accompanied by a map, and fills 53 of the 66 pages forming the number. There is a short paper of great interest on the Maori population of New Zealand, based on the last census of that colony. The writer (who does not give his name) discusses the causes of the dying out of the race, and also the attitude of the Colonial Government towards the Maories. There is a note from Prof. Kunze on the climatology of South America, and, lastly, a long list of barometrical observations by Lieut. François in the Kassai region.

THE SUN AND STARS[1]

VI.

Summary of Results

IN what has gone before we have found that the prominences, and the spots, have special spectra unlike the ordinary spectrum of the sun, and unlike the spectra of the chemical elements.

Further, we know that when we proceed outwards to the spectra of the inner and outer corona we find ourselves very little better off, for, with the exception of hydrogen, there is no substance which is perfectly familiar to us; and finally, when we come to study the association of phenomena on the sun, we find that, exactly while the spots and prominences give us the greatest divergences from terrestrial conditions, solar facts indicate that these phenomena are allied in the most close and obviously important manner. We must henceforth consider that the spots and the metallic prominences and the faculæ represent different indications of the same solar action.

Now, to continue this part of the inquiry is fundamental for us. It is almost impossible to see a large spot at the edge of the sun, which is the place for observing it best, without finding this downrush towards the photosphere answered, so to speak, by an uprush from below the photosphere—without finding this downrush of cool, absorbing, dark-and-widened-line-producing material, re-echoed by an uprush of bright-lined substance.

There is one word which expresses, as well as anything I can think of, the impression which is made on one by the phenomena. There is a *splash*. Imagine an enormous cauldron of liquid iron, as hot as you like. Play some water into it from a hose; there will be a splash. The water, of course,

[1] A Course of Lectures to Working Men delivered by J. Norman Lockyer, F.R.S., at the Museum of Practical Geology. Revised from shorthand notes. Continued from vol. xxxiii. p. 543.

would be very violently heated; we probably might get some explosions, and as the result of these explosions some liquid iron might be carried with the liquid water which has entered into the liquid iron here and there. The metallic prominences always are close to spots. They almost always follow them like the faculæ. I might have told you, in fact, while talking of this, that of 1100 cases in which spots and faculæ have been observed together, in 581 the faculæ were to the left of, or behind, the spots. Only in 45 were they on the right or in front. We shall see the importance of this by and by.

If we can invariably, as we do, associate the descent of material which, though we do not see it falling, we know is there, and that it is relatively cool—*if we can associate these descending absorption-phenomena with a subsequent upward splash*, we must look upon the most intensely active prominences as being return upward currents, though in some cases it may be that what we see as the spectrum of a prominence at the limb is, in part, that of the vapour descending to form a spot.

The Sunspot Period

The next thing we have to do is to discuss the periodicity of the various solar phenomena, to which attention has already been directed. It is worth while again to refer to the two very interesting and important curves in which Prof. Spörer has recorded the results of his own observations.

When the spots are at their fewest the small number we do see begin in a high latitude N. or S., from 30° to 35°; as the spots increase in number and activity we get, at the maximum sunspot period, the chief appearances observed in middle latitudes—about lat. 18°; and then the mean latitude of the spot zone still gets lower and lower, until at the next sunspot minimum we get two systems of spots—one of them, lowest in latitude (about 8° N. and S.), ending the first cycle, and another in latitude 30° beginning the next. These are the salient features of the periodicity to which we have now to confine our attention.

It has been previously pointed out that there are other periodicities with a much shorter period than eleven years; certain changes are seen to occur among the quiet prominences. Still this is the main periodicity with which we are familiar on the sun; and what we have now to do is to endeavour to see whether we can follow all the phenomena in their changes.

The two last maxima occurred in the year 1871 and eleven years afterwards in 1882 and some time after that year. At those times we got the greatest amount of spotted area and the most intense solar action. Similarly the two last periods of minimum activity were in 1867 and eleven years afterwards in 1878.

Now, in order to investigate this question in the most satisfactory manner, I think, and I doubt not you will agree with me, that we should begin with the simplest case.

The Minimum

The simplest case is evidently that in which the sun is quietest. At first sight it may appear a little hazardous to talk about the sun being at its quietest; but we know, as a matter of fact, that there is a tremendous difference at different times in the solar activity along the lines to which reference has been made.

But in the light of what has already been stated let us suppose the sun at its quietest, what phenomena shall we see?

There will be very few of the ordinary tree-like prominences anywhere on the sun, and especially will there be a dearth of them near the poles and near the equator.

There will be faculæ, but the faculæ will be dim; they will not present the bright appearance they generally do, and what there are will be mostly confined to the regions of latitude comprised between 20° N. and 20° S.

If by means of a spectroscope we attempt to determine the chemical materials in the chromosphere, we shall find just those five lines only to which we have referred in the spectrum as ordinarily visible—that is, four lines of hydrogen, and one line named D_3.

Practically speaking, there will be no spots visible upon the disk; the disk will appear to be perfectly pure, almost equally illuminated throughout, barring always the darkening towards the limb.

As there are no spots, or only very small ones in high latitudes, there will be, we can easily understand from what has gone before, no metallic prominences whatever. The spectroscope searching right round the limb of the sun will gather no indications of violent action—no region giving us many lines—nothing but that simple spectrum of hydrogen to which I have already referred.

What, then, is the appearance put on by the corona if we can manage to get an idea of a corona at the minimum sunspot period? We see, the moment that question is suggested, how excessively important it is that all eclipses should be observed, whether they occur at the maximum or the minimum of the solar activity. Fortunately, since the year 1860 these wonderful phenomena have been observed with more or less diligence; and since the year 1871—that is fifteen years ago now—with few exceptions, not only have those eclipses been observed by the eye with great care, but photographs of the extremest value have been obtained.

Unfortunately, that first minimum to which I have referred—the minimum in 1867—took place practically before the general introduction of this perfect photographic record of eclipses; and there is no good photograph extant of that eclipse; but fortunately, good photographs were secured of the eclipse of 1878. You can imagine our American cousins did not let an opportunity like that of advancing knowledge slip; and the result was that the whole land along the line of totality bristled with telescopes and cameras, which did their work in an admirable way. So that in the eclipse of 1878 we did get a photographic record, that is to say, an absolutely trustworthy record, of the appearance presented by the sun's corona at the minimum sunspot period. If it were not so, I should have hesitated to show you the drawing made in 1867; but I think you will say, when I show you these records together, that the drawing in 1867 is so like the photograph taken in 1878 that on that ground alone it is worthy of extreme confidence; and if we can accord such confidence to it, we arrive at the very important conclusion that at two different sunspot minima the appearances presented by the corona were very much alike indeed.

At the minimum period the chief feature is a tremendous extension of the corona in the direction of the solar equator. At both the poles, north and south, there is a wonderful curving right and left; this outcurving having been one of the most exquisite things which it is possible to imagine.

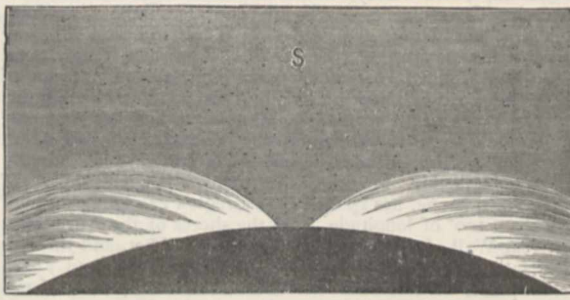

FIG. 19.—Outcurvings at the solar poles (1878).

There is further evidence indicating that the equatorial extension on the photograph may only after all have been a part of a much more extended phenomenon, one going to almost incredible distances—considering it as a solar atmosphere—from the sun itself.

It has already been stated that at that eclipse one observer took extreme precautions to guard his eyes from being fatigued by the light of the inner corona, which sometimes is so bright that observers have mistaken it for the limb of the sun itself. What this gentleman, Prof. Newcomb did, was to erect a screen which covered the moon and a space 12′ high round it. The result was, that as soon as he took his station at the commencement of totality, he saw a tremendous extension of the sun's equator on both sides the dark moon, the extension being greater than that recorded in the photograph. It does not follow that the photograph gives us the totality of the extension; it may be that the extended portions may have been so delicately illuminated, that they would not impress their image on the photographic plate in the time during which that plate was exposed, or that the light itself is poor in blue rays. So considerable was this extension, amounting to six or seven diameters of the dark moon, which practically may be taken to be the same as that of the sun behind it, that Prof. Newcomb had at once suggested to him the zodiacal light. It happened that while this eclipse was being observed by Prof. Newcomb and myself—we were practically close together at a height of 7000 feet—other observers were viewing the eclipse from Pike's Peak, some few hundred miles away, at a height of 13,000 feet. You can imagine the purity of the air at that height; there was not too much of it—so little in fact that some observers had to go down. These saw the corona very well indeed; and one or two observers, without taking the precaution of putting up a screen, saw an extension almost comparable with that recorded by Prof. Newcomb.

That, then, we must take to be the undoubted result arrived at during the eclipse of 1878, which happened at the last sunspot minimum. We have a tremendous equatorial extension; that is the great feature, and it is proved by photographs.

The drawing made in 1867 gives us the same result. We again get the equatorial extension east and west, and the wonderful outcurving right and left from the sun's poles.

Hence, then, we must associate a corona of that kind, *i.e.* having a considerable equatorial extension, with that quiet condition of things at the sun, during which metallic prominences, ordinary prominences, faculæ, and spots show a minimum of activity.

You will remember that we saw from the sunspot curve that from minimum to maximum it mounts rapidly, reminding one of a steep cliff. We have in fact only three years from minimum to maximum, while we have eight years from maximum to minimum.

The Approach to Maximum

We have then next to consider the solar condition between minimum and maximum. We must suppose ourselves to be half-way up the steep part of the curve that connects the maximum with the minimum. In this case we find a greater activity in all directions. The hydrogen—or the quiet—prominences are more numerous. The faculæ are brighter. If we now examine the chromosphere we find hydrogen and D^3 are not the only constituents—we get those other short lines added of which Prof. Tacchini has given us such a valuable list, among them chiefly being those three lines of magnesium which are designated b^1, b^2, b^4. That is the chemical difference between the chromosphere of the sun at this time, and the first period at which we considered it. The spots also are more numerous, and what spots there are we have in a lower latitude; instead of making their appearance in latitude 35°, they will be nearer latitude 25°—they will have come down 10° from the solar poles towards the equator. These more numerous spots will also be constantly accompanied by metallic prominences, and the number of lines visible as bright lines in these prominences we shall find increasing as the observations are made month after month.

How about the outer atmosphere of the sun? Well, remarkable changes begin to take place in it too. In considering the minimum corona I said nothing about its spectrum, for the reason that I wished that wonderful bilateral and symmetrical and simple form to rivet the attention. But now it is right that I should say that one of the chief changes between this corona as the maximum is approached and the minimum one is not only the change of form to which I shall have to draw attention, but a change in the spectrum. At the minimum sunspot period the corona gives exactly, or very nearly exactly, the same spectrum as the limelight or a jet of gas—we get very nearly a continuous spectrum. The chief difference between the spectrum of the corona, then, and the spectrum of the gas jet, is that in this continuous corona spectrum certain dark lines will be seen, but no very obvious bright lines are there. We therefore have to come to the conclusion that at the minimum the corona is not chiefly gaseous in its spectrum, but that it consists of solid particles to a very large extent; and that these solid particles are not only competent to reflect light, but that they actually do reflect light coming from the lower portions of the sun; and in that way we account for the presence of the Fraunhofer lines.

But when we come to the second period we are now discussing, these change to a very large extent; the spectrum is no longer continuous; bright lines begin to make their appearance, and with this coming-in of bright lines comes in a greater brilliancy.

And then as to the form. The diagram is copied from a drawing taken in the year 1858, at exactly the right period to illustrate any change which may have taken place on the approach to maximum. Unfortunately it is not a photograph. Those who lecture in this theatre twenty or a hundred years after me will be under many better conditions than we are, because they will have a more complete series of photographs to refer to; but in the absence of photographs we must do the best we can. Strange though the drawing is, it brings together so many features seen in other eclipses, that there is very little doubt that it is near the truth. However that may be, it must be acknowledged that between the last drawing you saw and this

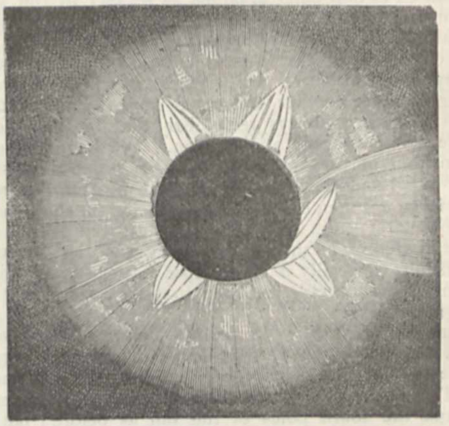

FIG. 20.—Corona of 1878.

there is a most enormous difference. The remarkable point about it is that we have no special feature in the equatorial zone: we get a streamer here with very strange outlines, and we get another there, but the point of this drawing is that we get in middle latitudes, north and south, four wonderful luminous cones, and the amount of light and structure in the corona has increased to such an extent, that that exquisite, that beautiful tracery and double curves—curves east and curves west—we saw at both poles at the minimum, are now hidden in a strong radiance. So much then for the second act, so to speak, in this solar drama.

The Maximum

We next deal with the maximum period when all the solar forces are working full time, and when we get both in prominences and in spots, and indeed in every outcome of action that we can refer to, indications of the most gigantic energies at work, and the most wonderful changes produced; energies and changes displayed from one pole of the sun to the other. When we come to this period of enormous action, we shall find that, although it becomes more general in one sense, it is really more limited in another.

The ordinary prominences, instead of clinging to the equator as they have done previously, are now found to be most frequent at the solar poles; the faculæ are brighter and more spread over the solar surface than they have ever been before. The chromosphere is richer in lines.

The spots occupy broad zones, the mean latitude being in about 18° N. and S. No spots near the poles, no spots near the equator, but spots indicating enormous activity and of enormous area, surrounded by gigantic faculæ, will be seen following each other in these zones. We shall find every one of these indicators of solar activity accompanied by enormous prominences. It is at this time we get the greatest velocities of upthrow in the prominences, and the greatest indications of tremendous downward velocity in the vapours which form the spots. It is at this time we get the spots riddled by bridges of intense brilliancy, full of veiled tints, red, yellow, blue, and violet, and all those other more delicate and beautiful phenomena described by M. Trouvelot and others, to which I have drawn attention.

How about the outer atmosphere of the sun? What has happened to that? Here, fortunately, we have the photographic records of two years—of two maximum years—to study. In these records there is no doubt that we have a thing which is absolutely and truly solar, for the reason that the photograph has undoubtedly, I think, sifted out what may be considered as due to non-solar causes. I say this distinctly, because I was fortunate enough to see both of these eclipses, one in India, and one in Egypt, and certainly there were things which I saw with the naked eye which one does not see in the photographs. We will consider the eclipse of 1871 first.

We see in a moment that we have something here at the maximum sunspot period different from what we have had before. To compare it with the record of the preceding minima in 1867 and 1878. Instead of having streamers limited to the equator, they exist in high latitudes, and instead of having them limited to four chief maxima, as we had in the year after the minimum in 1868, the energy is now so great that they practically extend to every part of the sun.

The directions of the lines of force, as they may be called, are very various: there are straight rifts; there are curved boundaries; here another streamer is curved bodily, and so we go on. We must always remember that in this photograph what we see is, after all, a projection. We have the spherical moon in front of the spherical sun, from which these streamers project in all longitudes—some straight towards the earth, the tips of which are seen over or under the moon, some more sideways from parts of the sun nearer to or further from the eye than the central section, so that the unravelling of the appearances is very difficult, especially if the eclipse happens when either the sun's north or south pole is tipped towards us or away from us to the greatest extent.

So much for 1871: in another eleven years we have another maximum—that of 1882—an eclipse seen in Egypt. In this case we find the activity more general than in the former one. The top and the bottom of the diagram represent the north and the south poles of the sun as before; but we see now that the streamers are more broken up, and furthermore that the rifts visible round the north and south pole at the previous maximum are entirely covered up—not that the rifts were not there, but that one could not see them in consequence of the extreme brilliancy of the streamers that were thrown towards the eye from the sun between us and the plane passing through the solar poles.

Independently of that, it is easy to recognise that there is a tremendous family likeness between the photographs taken at both maxima, whereas there is the greatest possible difference between either of them and the drawings or photographs taken at the minimum sunspot period. If we accept that, that is a very great step gained.

After Maximum

We need not, after what has gone before, take up any more time, which is short, by discussing the gradual descent to minimum. I say the *gradual* descent because we know there are more years consumed in going from maximum to minimum than from minimum to maximum.

Of course all the various energies slacken down, the mean latitude of the spots and metallic prominences still getting lower till they reach lat. 8° N. and S.; then another series of spots breaks out in lat. 35° N. and S., and the whole story begins anew.

Summary

Now let us deal with the results we have arrived at. At the maximum period the continuous spectrum of the corona gives way almost entirely to a spectrum of bright lines. When I say gives way almost entirely, I mean so far as this: the striking thing when you observe the spectrum of the corona at the maximum period is a series of brilliant lines, or of brilliant circles, according as we use a slit, or simply look through a prism, and the brilliancy of the spectrum seen between these lines or rings is small compared with the brilliancy of the lines or rings. That indicates that the temperature of the gases in the corona is greater than the temperature of the other substances, and of course is very much higher than it is during the time of the minimum, when the gases do not make themselves visible, and, as I said before, the chief spectroscopic effect obtained is the continuous spectrum with dark lines here and there, showing that some part of the light is derived from cooled solid particles which can and do reflect light from the subjacent photosphere.

To deal with results, and to bring them together as sharply as may be, we find, first, that the dimness of the light and absence of bright lines at the minimum shows that the outer atmosphere of the sun is cooler at the minimum sunspot period. When I was in America in 1878, at the period of minimum to which we have referred, I saw at once that the corona was not anything like so brilliant as I had seen it previously in 1871 in India. Eventually, when the observations came to be discussed, the conclusion arrived at was that the brilliancy was not one-seventh of what it was at the previous maximum. There is a very considerable difference which no one can mistake who observes one eclipse after another.

Secondly, when the corona is thus cooler, and therefore dimmer, an extension in the plane of the sun's equator is seen. A question arises here whether this extension is not seen at the maximum because the eye is so much affected by the very brilliant corona? That is a subject which will require to be investigated in subsequent eclipses.

Thirdly, there are plenty of minor prominences at the minimum sunspot period; there are no spots, or very few.

Fourthly, the lower temperature, and therefore relative quiescence, of the solar atmosphere seems to depend on the absence of spots. That is an important matter; and the point I wish to make is this: the quietude cannot depend on the absence of prominences, because they are there—not so many of them, but still some prominences.

Fifthly, when the spots begin in these higher latitudes, 30° or 35°, as we have seen, we get the first brightening of the corona.

Sixthly, the coronal streamers follow the spots—by which I mean that the cones and coronal streamers put on their greatest intensity according as the spots have moved nearer to the equator. When we have the minimum sunspot period, you can hardly call that equatorial extension a streamer at all, because it is so very dim; and further, I take it, it is really of a different nature and origin.

The Circulation in the Sun's Atmosphere

If we make an attempt to discuss the circulation of the atmosphere, a question which we acknowledge to be an extremely difficult one, we must bear in mind the enormous difference between solar and terrestrial conditions. When a portion of the earth's surface is heated in a whole zone—as the equator is in the tropics—by the sun, you see the heat is outside, an ascending current is formed, and winds from north to south set in. For instance, if we consider the equator, and suppose the sun to be over it, we get the earth's atmosphere over that region more highly heated than those parts of the atmosphere near either pole; and the result is, we get an indraught current in that way, both from the northern and southern hemispheres. In consequence of these two currents meeting and beginning their ascent at some distance from the equator, we get a belt of calms, of reduced pressure, and we get almost perpetual rains.

Now, you see, that is all very well as a piece of terrestrial meteorology, but it is of no value to us from the solar point of view, unless it sets us thinking how very different the conditions are.

The sun cannot be heated from the outside. We have seen, in fact, that one chief point about the sun is that it is cooled on the outside; that masses of gas going up to tremendous altitudes eventually arrive where the atmosphere is cold and quiet, and where they again take on the solid or liquid forms, when they begin to go down again. Now the sun, if it is heated at all, must be heated from the inside. What do I mean by the inside? I mean—seeing that the phenomena we have been discussing in these lectures take place outside the photosphere—that the inside must be something below the level of the photosphere. Now what form must that heat take? It will take, as undoubtedly we see in the metallic prominences it does take, the form of the ejection of the tremendously brilliant and incandescent vapours. How are these produced? Something must produce them; they do not ascend of their own sweet will, or they would not come up so locally as we see them.

We get this fact most indisputably, which I hope I have been able to make quite clear, that these ascents of vapours from below the spot region always accompany the spots, and they always follow the spots in time. Then is it not reasonable to suppose they are produced by the spots? You remember I objected to the word "eruption" in connection with these prominences. I do not so much object to the word "explosion," for I cannot understand how if you get twenty million tons of meteorites falling down in a particular latitude of the sun, and plunging into the photosphere—I do not understand how there must not follow after that the most gigantic and terrific explosion, driving heated gases many hundreds and thousands of miles into the upper air along the line of least resistance, and disturbing the photosphere for months afterwards. Now that really does seem to be the plain English of what happens.

I have told you that in the origin of the spots the first disturbance is the formation of a few little openings probably by the advanced guard of the falling solid material. In a few days, by the continuous downpours, these develop into a spot. This spot is followed by a metallic prominence sending up the masses of gas at the rate, may be, of 250 miles a second—a rate Prof. Young has observed; and after that the faculæ appear. I throw that idea out because the greatest prominences are associated with the greatest spots; the spots begin the disturbance, and the energies radiate from the point where we first see the disturbance, which, I repeat, the spot begins.

We see, then, that on the sun the action will be almost just the opposite of what it is on the earth. We get first of all the descent of cooled matter on to the part of the sun where the disturbance begins.

Here we get ascent in consequence of greater heat outside. At the sun the greater heat inside the sun is liberated by the splash and explosion of spot-producing material.

Now, when the material falls in the way we have indicated, we shall get, if the idea is true, a considerable temperature in the region above the fall accompanying the return current in the shape of prominences. We may probably also get a current in the lower atmosphere set up towards the north and towards the south, and another thing we shall certainly get will be a tremendous brightening of this part of the solar atmosphere.

One of the great differences between one part of the solar atmosphere and another depends upon its temperature; so that you must imagine that the moment we get any great change in the temperature of any part of the atmosphere we must get a great change in its brilliancy, even in the higher regions: this may explain the streamers.

If there are these lower currents towards the poles there will probably be upper currents away from them which may in some way locate spot-forming material over the spot zones. On this subject, however, which, though one of the most important in solar physics, is one in which we see our way least clearly, I have not time to enter.

J. NORMAN LOCKYER

(*To be continued.*)

THE INSTITUTION OF MECHANICAL ENGINEERS

THE Institution of Mechanical Engineers held their annual meeting, under the presidency of Mr. Jeremiah Head, at the Theatre of the Institution of Civil Engineers, on the 6th and 7th inst.

Mr. T. B. Lightfoot read a paper on refrigerating and ice-making machinery and appliances. He commenced by describing a complete refrigerating machine as an apparatus by which heat is abstracted, in combination either with some system for renewing the heat-absorbing agent, or, as is more usually the case, with a contrivance by which the abstracted heat is rejected and the agent is restored to a condition in which it can again be employed for cooling-purposes.

The first method by which heat is abstracted by the rapid fusion of a solid is probably the oldest. It depends upon the very strong tendency of mixtures of certain salts with water or acids, and of some salts with ice—which form liquids whose freezing-points are below the original temperatures of the mixtures—to pass into the liquid form; heat is absorbed more quickly than it can be supplied from without, and the temperature consequently falls. This method has been mainly employed for domestic and laboratory purposes.

When heat is abstracted by the second method, that is, by the evaporation of a more or less volatile liquid, other things being equal, the liquid with the highest latent heat will be the best refrigerant, because for a given abstraction of heat, the least weight of liquid will be required, and therefore the power expended in working the machine will be the least. There are four different kinds of processes employed.

The first, in which the refrigerating agent is rejected with the heat it has acquired, is generally known as the vacuum process. Water, the only agent cheap enough to be employed, must be reduced to a pressure below 0·089 lb. per square inch, which is the pressure of water-vapour at the temperature of melting ice. A vacuum-pump is employed, combined with a vessel containing strong sulphuric acid, for absorbing the vapour from the air drawn over, and so assisting the pump. Lately an improvement has been effected in this process by the employment of a pump with two cylinders and intermediate condenser, the water being admitted to the ice-forming vessels in fine streams, so as to offer a large surface for evaporation. The second, or compression-process, is used with liquids whose vapours condense under pressure at ordinary temperatures. The first apparatus employed, though in some respects crude, is yet the parent of all compression-machines used at the present time, the improvements being generally in matters of constructive detail. The water to be frozen was placed in a jacketed copper pan, the jacket being partially filled with the volatile liquid, and carefully protected on the outside with a covering of non-conducting material. A pump drew off the vapour from the jacket, and delivered it compressed into a worm, around which cooling water was circulated, the pressure being such as to cause liquefaction. The liquid collected at the bottom of the worm, and returned to the jacket through a pipe, to be again evaporated. Most modern machines comprise a refrigerator, a water-jacketed pump, a condenser, and ice-making tanks containing moulds or cells, around which brine cooled to a low temperature in the refrigerator is circulated by means of a pump. The working pressure in the refrigerator depends upon the reduction in temperature desired, the higher the pressure the greater being the work that can be got out of any given capacity of pump. The liquefying pressure in the condenser depends on the temperature of the cooling water, and on the quantity that is passed through in relation to the quantity of heat carried away; this pressure determines the mechanical work to be expended. To produce transparent ice, the water has to be agitated during freezing, so as to allow the air to escape. Various refrigerating media have been used, such as ether, sulphur dioxide, and anhydrous ammonia. The third is known as the absorption process: the principle employed is chemical or physical rather than mechanical, and depends on the fact that many vapours of low boiling-point are readily absorbed by water, but can be separated again by the application of heat to the mixed liquid. Taking advantage of the fact that two vapours, when mixed, can be separated by means of fractional condensation, an absorption machine has been brought out in which the distillate was very nearly anhydrous. Ordinary liquid ammonia of commerce was heated, and a mixed vapour of ammonia and water was driven off. By means of vessels termed the analyser and the rectifier, the bulk of the water was condensed at a comparatively high temperature and run back to the generator, while the ammonia passed into a condenser, and there assumed a liquid form. The nearly anhydrous liquid was then evaporated in the refrigerator in the ordinary way; but, instead of the vapour being drawn off by a pump, it was absorbed by cold water or weak liquor in a vessel called an absorber, which was in communication with the refrigerator, and the strong liquor thus formed was pumped back to the generator and used over again. In the fourth, which is known as the binary absorption system, liquefaction of the refrigerating agent is brought about partly by mechanical compression and partly by absorption; or else the refrigerating agent itself is a compound of two liquids, one of which liquefies at a comparatively low pressure, and then takes the other into solution by absorption. An interesting application of this system has been recently made by Raoul Pictet, who found that, by combining carbon dioxide and sulphur dioxide, he could obtain a liquid whose vapour-tensions were not only very much less that those of carbon dioxide, but were actually below those of pure sulphur dioxide at temperatures above 78° Fahr. This very remarkable and unlooked-for result may open up the way for greater economy in ice-production.

The third method is that in which machinery is used by which gas is compressed, partially cooled while under compression, and further cooled by subsequent expansion in the performance of work, the cooled gas being afterwards used for abstracting heat. This method has been much employed of late years, under the title of "Cold-air machines" for the preservation of meat and other perishable food. The author has designed machinery of this class, in which a weight of 1000 lbs. of air per hour can be reduced from 60° above to 80° below zero Fahrenheit, with cooling water at 60° F., with the expenditure of about 18 indicated horse-power. The air after being compressed in the compresser passes to the coolers, which consist of a couple of vessels containing tubes, through which water is circulated by a pump. The compressed air passes through one cooler and returns through the second, being cooled to within 5° or 6° of the initial temperature of the cooling water, which circulates in a direction opposite to that of the air. From the coolers the air passes to the expansion cylinder, and after performing work upon the piston, and returning about 60 per cent. of the power expended in its compression, it is exhausted, having been cooled down from 70° above to 90° below zero Fahr. Besides its application to the importation of dead meat, live cattle, &c., an interesting application was made last year in the construction of a tunnel through a hill in Stockholm, in the excavation of which, some running ground was met with, consisting of gravel mixed with clay and water, which it was determined to freeze. The innermost end of the tunnel next the face was formed into a freezing-chamber by means of partition walls, which were made of a double layer of wood filled in between with charcoal. The temperature of the freezing-chamber was generally from 6° to 15° below zero Fahr. after twelve hours' running, but soon rose to freezing-point when the men began to work. The tunnel was driven through its length of 80 feet with entire success, the daily progress averaging about 1 foot.

A paper on the distribution of the wheel-load in cycles, illustrated by means of fifty-six figures, was read by Mr. J. Alfred Griffiths. The author gives the following five points of efficiency as applying to cycles generally, viz. reduction of dead weight by the avoidance of very large wheels and of heavy or purely ornamental or unnecessary framing; reduction of resistance by avoidance of very small wheels, and by employment of the best designs in bearings and in driving-mechanism for the diminution of internal friction; perfection of load distribution by entire avoidance of wheels that neither transmit motive-power nor assist the steering, and by concentration of the load on the driving-wheels and reduction of that on the steering-wheels; stability when at rest and when in motion on the straight and round curves, when on a smooth surface and also on a rough and lumpy road, and when the brake is applied either suddenly or gradually; arrangement of load and driving-mechanism so that the distribution of the wheel-load shall be as good on rising or falling gradients as on a level. Tables of dimensions and distribution of wheel-load were appended.

A paper on the raising of the wrecked steamship *Peer of the Realm*, which was effected by the platforming method, and without the aid of divers for any part of the operation, was read by Mr. T. W. Wailes, of Cardiff.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

OXFORD.—The Council of Somerville Hall have decided to build additional rooms for twenty students. Two Entrance Scholarships of 35*l*. and 40*l*. a year are offered for competition on May 25.

SCIENTIFIC SERIALS

American Journal of Science, March.—Examination of Dr. Croll's hypothesis of geological climates, by Dr. A. Woeikof. The author subjects Dr. Croll's theories to a searching criticism, traversing all his fundamental principles. The statement that the ocean must stand at a higher *mean* temperature than the land is shown to be quite erroneous, the oceans which receive cold currents from Polar seas, and even seas like the Mediterranean and Red Sea, which receive no such currents, having a mean temperature considerably lower than the continents. His whole system of estimating temperature breaks down when seriously tested, the errors being enormous, in some cases upwards of 100° F., or greater than the difference of annual temperature between the equator and the North Pole. His hypotheses, although brilliant and fascinating, cannot be accepted, the main points on which they rest being opposed to the most certain teachings of meteorology, and the whole fabric in its explanation of glaciation and geological climates generally being entirely fallacious.—Tendril movements in *Cucurbita maxima* and *C. Pepo* (concluded), by D. P. Penhallow. The author concludes generally that growth is promoted by an increase of temperature and humidity, but may be retarded by an increase of temperature when other conditions are unfavourable. It is also retarded by excessive transpiration, while the conditions favourable to growth, arising from temperature and humidity, may cause greater growth during the day in opposition to the retarding influence of light. Movements of tendrils and terminal buds, being phenomena of growth, are modified by whatever variations of condition affect growth.—Note on a method of measuring the surface-tension of liquids, by W. F. Magie. It is shown that Poisson's formula determining approximately the height of a large liquid drop standing on a level plate holds good, without any change, for a bubble of air formed in a liquid under a level plate.—Remarks on W. B. Rogers's "Geology of the Virginias" (continued), by J. L. and H. D. Campbell. In this concluding paper the authors deal with the most salient points in the higher formations of the geological system of Virginia and West Virginia. Their remarks, based mainly on personal observation, are intended to be supplementary to Mr. Rogers's comprehensive treatise on the geology of this region.—Observations on the Tertiary of Mississippi and Alabama, with descriptions of new species, by D. W. Langdon. An important result of these observations is the establishment of the relation of the Jackson beds to the Orbitoides limestone and marl beds of Byram Station. The new species, which will be figured in the forthcoming Report of the Geological Survey of Alabama are: *Verticordia eocensis*, apparently the first Verticordia described from this epoch; and *Bulla* (*Haminea*) *aldrichi*, an elongate oval shell resembling *Bulla glaphyra*, Desh.—On the area of Upper Silurian rocks near Cornwall Station, Eastern Central Orange County, New York, by Nelson H. Darton. The paper contains a careful study of the Towsend Iron Mine district and vicinity, where a small mass of Lower Helderberg limestone has been protected from the general denudation by a firm backing of coarse strongly cemented sandstones. The whole forms a ridge running just west of Cornwall Station, its more prominent geological features being shown on the accompanying map.

Rivista Scientifico-Industriale, March 15.—On the crepuscular lights that followed the Krakatão eruption, by Prof. Alessandro Sandrucci. The author surveys with Hirn the various theories propounded to explain this phenomenon, and rejects them all as inadequate, or else based on impossible assumptions. He concludes that for the present the after-glows must be classed with the numerous effects the causes of which have not yet been fathomed.—On the origin of atmospheric electricity, by Prof. Luigi Palmieri. A simple experiment is described, by which it is clearly shown that positive electricity is generated by the moisture of the air, when it becomes condensed by a lowering of the temperature. This conclusion is reconciled with the theory recently advanced by Prof. Edlund, of Stockholm, who argues that the electricity of the air is derived from the earth by the unipolar induction of terrestrial magnetism, while its return to the earth is caused by the condensation of the aqueous vapours, and especially by their conversion into the fluid state.

Rendiconti del Reale Istituto Lombardo, April 1.—Reptiles of the Orta-Kenei district, Adrianople, by Prof. F. Sordelli. This is an account of the collection recently made at the southern foot of the Balkan Range by the Cavaliere Luigi de Magistris, and by him presented to the Civic Museum of Milan. Of over twelve species of reptiles three only are found in the Po Valley, all the rest being of an essentially Eastern character, with a range extending from the Balkan Peninsula to the Iranian Plateau.—Note on a fundamental theorem in the theory of the functions of a complex variable quantity, by G. Morera.—Stratigraphic observations in the province of Avellino, by Prof. T. Taramelli. The paper contains a systematic study of the stratified rocks exposed by the cuttings of the Avellino and Santa-Venere line of railway, and ranging through the whole series from the Lower Chalk through the Eocene, Miocene, and Pliocene, to the more recent Quaternary formations.—Account of a rare and interesting ornithological specimen, by Prof. Pietro Pavesi. The author describes a fine specimen of *Bernicla leucopsis*, Bechst., recently shot at Corana in the Po Valley, and now preserved in the Civic Museum of Pavia.—On the rational curves in a linear space to any number of dimensions, by A. Brambilla.—Meteorological observations made at the Brera Observatory, Milan, during the month of March.

SOCIETIES AND ACADEMIES

LONDON

Zoological Society, May 4.—Prof. W. H. Flower, LL.D., F.R.S., President, in the chair.—Mr. E. L. Layard, F.Z.S., exhibited a fine example of a rare Beetle of the family Cerambycidæ (*Macrotoma heros*), obtained in the Fiji Islands; and a series of specimens of shells of the genus Bulimus from New Caledonia and the adjacent islands.—A letter was read from Mr. F. W. Styan, F.Z.S., relating to some Chinese animals of which he had lately obtained specimens.—Mr. W. F. Kirby read some remarks on four rare species of Sphingidæ, of which he had lately examined specimens.—Mr. F. E. Beddard read a paper containing observations on the ovarian ovum of Lepidosiren (Protopterus), and described the entrance of follicular cells into the interior of the ovum. It was believed that these cells played an important part in the formation of the yolk.—Mr. Beddard also communicated a paper by Mr. J. T. Cunningham, on the mode of attachment of the ovum of the smelt (*Osmerus eperlanus*).

PARIS

Academy of Sciences, May 3.—M. Jurien de la Gravière, President, in the chair.—On the magnetic principle, by M. Mascart. The author's theoretical studies lead to the general inference that, in a magnetic and isotropic body of any form there are three rectangular directions for which the magnetic force is parallel to the outer field with different coefficients, f, f_1, and f_2. These coefficients possess the same properties as those of a sphere of slightly magnetised anisotropic substance. For steel the mean coefficient of longitudinal magnetic force is much weaker than for soft iron; hence the increased importance of transverse magnetisation.—On the formation of oxalic acid in plants: a study of *Rumex acetosa* (sorrel), by MM. Berthelot and André. The analysis of the dried seeds of this plant yielded 0·05 per cent. of oxalic acid, which is also largely present in the leaves and stalk, but to a less degree in the root.—Remarks on MM. Berthelot and André's communication on the proportion and quantitative analysis of the ammonia present in the ground, which appeared in the last number of the *Comptes rendus*, by M. Th. Schlœsing. The author takes exception to MM. Berthelot and André's account of his process for effecting the analysis, and also traverses the statement that arable land, when irrigated, tends constantly to liberate the ammonia of the ammoniacal salts contained in it.—On holmine, or M. Soret's earth X, by M. Lecoq de Boisbaudran. This was a sealed paper recently deposited with the Academy, and now opened at the author's request. It shows that holmine contains at least two metallic radicals.—On dysprosium (symbol Dy), by M. Lecoq de Boisbaudran.—Remarks on a work entitled "Science and Philosophy," presented to the Academy by the author, M. Berthelot.—Observations on the new comet 1886 *a* (Brooks I.), made at the Paris Observatory (equatorial of the West Tower), by M. G. Bigourdan.—On the spectrum of the Fabry Comet, by M. Ch. Trépied. In this comet, as in that of Encke, there appears to be a predominance of the gaseous elements on the one hand, while on the other its spectrum seems to show that the relative brightness of the nucleus bears no necessary relation to the degree of condensation of the cometary matter.—On the density of liquid atmospheric air and its constituent elements, and on the atomic volume of oxygen and nitrogen, by M. S. Wroblewski.—Practical method for the preparation of the Nicol and Foucault prisms (three illustrations), by M. L. Laurent.—On the penetration of light into deep seawater, by MM. H. Fol and E. Sarasin. From the author's experiments it appears that layers at a depth of 300 metres are illumined every day for the whole time that the sun remains above the horizon; at 350 metres light penetrates for at least eight hours daily. Even after sunset the actinic rays seem to reach considerable depths.—On the combinations of phosphoric acid with titanic acid, zircon, and stannic acid, by MM. P. Hautefeuille and J. Margottet. The general conclusion of the author's researches is that the phosphates of titanic acid, zircon, and stannic acid possess the atomic composition of the phosphate of silica. By employing phosphoric acid as a dissolvent they can be obtained only under the octahedric form, while the phosphate of silica is obtained not only under this but under three other forms incompatible with the first.—Action of vanadic acid on the ammoniacal salts, by M. A. Ditte.—On the constitution of butter, by M. E. Duclaux.—On xenotime, a rare mineral from Minas Geraes, Brazil, by M. H. Gorceix. This substance, which on analysis yields PhO_5, 35·64, YO + ErO, 63·75, and insoluble residuum 0·4, appears to be a phosphate of yttria and of a second earth, very probably erbine.—On the endothelium of the inner wall of the vessels in invertebrates, by M. W. Vignal.—On the existence in birds of a series of cephalic ganglia of sympathetic character, corresponding to the segmentary cranial nerves, by M. F. Rochas.—Researches on the structure of the stomach in birds, by M. M. Cazin.—On *Entoniscus mænadis*, a parasite infesting the *Carcinus mænas* crab, by M. A. Giard.—On some phenomena connected with the division of the cellular nucleus in plants, by M. L. Guignard.—Remarks on M. Boutroux's recent communication on an acid fermentation of glucose, by M. Maumené. The author shows that this acid differs in no respect from that already determined and described by him in the year 1875, under the name of "hexepic."

BERLIN

Physiological Society, March 26.—Dr. Kossel communicated the results of experiments instituted by Dr. Schotten respecting the cholic acids. As was known, two different nitrogenous acids entered into the composition of the bile, glycocollic acid and taurocholic acid, which broke up respectively into glycocoll and cholalic acid, and into taurin and cholalic acid. The constitution of this azoteless acid, common to both, had not yet been determined. It was, however, known to be different with different animals. In the bile of horned cattle two cholalic acids had been found, distinguished as taurocholic acid and choleic acid. In the bile of swine a third cholalic acid had been found, hypocholalic acid; and in the bile of geese, a fourth, chenocholalic acid. It was probable that still more cholalic acids would be discovered. Dr. Schotten's studies had for their object the elucidation of the constitution of cholalic acid. By heating to 300° C. he was able to split two molecules of water, and to obtain a body of an equal quantity of carbon, a less quantity of hydrogen and of oxygen. By subjection to a still greater degree of heat, from two molecules of the acid a molecule of water was separated, and a substance obtained consisting of two groups of atoms connected by an atom of oxygen. By treatment with anhydrous acetic acid Dr. Schotten established that cholalic acid was both monobasic and monovalent. Finally he investigated the composition of human bile from 350 gall-bladders, with a view to testing the statement that in human bile was contained a peculiar cholalic acid, the anthropocholalic acid of Herr Beyer. Although at first he received the same results, viz. a salt of baryta containing much less carbon than the other cholalic acids, yet subsequently, by continued purification and transcrystallisation of the product, he came to the conviction that in the human bile only the taurocholic acid of horned cattle was present. The results at first obtained of apparently different significance were due to the fact that the soluble barytic cholalate with carbonate of barium very readily formed insoluble double salts which were not easily split.—Dr. Biondi spoke on the intermaxillary bone, and discussed the fact that the doctrine set up by Goethe, that on each side but one intermaxillary bone was developed, namely from the frontal process, while the superior maxilla, on the other hand, was evolved from the maxillary process of the skull, had, in the year 1879, been replaced by a new doctrine advanced by Herr Albrecht. According to this new doctrine two intermaxillary bones were developed on both sides, growing out of the lateral and median frontal process, and then coalescing with the superior maxilla from the maxillary process. According to the older view, at present defended in particular by Dr. Kölliker, the hare-lip originated between superior maxilla and intermaxillary bone. Prof. Albrecht, on the other hand, removed the position of the hare-lip to between median and lateral intermaxillary bone. By way of proof for this latter view, the circumstance was adduced that externally from the fissure an incisor tooth was regularly found. Dr. Biondi had examined a very large number of normal and pathological skulls, and had followed the development in embryos of the facial bones. Like Prof. Albrecht, he regularly found an incisor tooth externally from the hare-lip fissure, and, in the case of embryos, in the intermaxillary bone two points of ossification, whence were developed two separate intermaxillary bones. Between these two were situated the hare-lip fissure and that of the palate. The views of Dr. Biondi and of Prof. Albrecht deviated on the contrary very materially from each other respecting the place where the two intermaxillary bones originated. In accordance with the speaker's views, the superior maxilla and the outer intermaxillary bone developed from the maxillary process, while, on the other hand, the inner intermaxillary bone sprang from the median frontal process. The lateral frontal process did not reach so far down. The hare-lip, in point of fact, therefore, as had been maintained by earlier authorities, was situated between the maxillary and frontal process. The upper lip, in the opinion of the speaker, developed itself, in perfect accordance with the relations obtaining in respect of the superior maxilla and its alveolar margin, out of the maxillary process and the inner frontal process, while the outer frontal process formed the alæ nasi. In respect of the two intermaxillary bones on each side, the presence of which the speaker assumed along with Prof. Albrecht, Dr Biondi deviated from the latter in so far as that he had found, not an outer and inner intermaxillary bone on each side, but an anterior and posterior. The incisor teeth, as also the supernumerary teeth, developed themselves only in the intermaxillary bone. Dr. Biondi illustrated his address by preparations, drawings, and photographs he produced.—Dr. Pohl-Pincus next gave a supplement to his address on the polarisation colours of the hair of the human head, adducing the reasons which determined him to lay down three types of colouring: the normal, the pathologic, and an intermediate type. It was nevertheless to be understood that a whole series of transitionary hues intervened between the two extremes. He further stated that, in accordance with his experience, hair pathologically changed in its double refraction in consequence of stimulation from inflammation or from psychical excitement was long in returning to its normal condition. The speaker next described two experiments on a frog's heart. When he removed from a frog the anterior part of the cerebrum, under avoidance of heavy bleedings, then set free the heart, and stimulated one or several sensory nerves of the body, he then observed that the systole of the heart was unchanged. During the diastole, however, there appeared on the surface a chess-board-like drawing, and the diastole itself was interrupted in the middle by an intermission. By stimulation of the vagus he was able to overcome this effect of the irritated sensory nerves. The second observation he communicated respected the local diastole which a considerable time previously had been noticed by others as well as by himself. The occurrence of this diastole under local mechanical stimulation of the frog's heart was always a very uncertain one. Dr. Pohl-Pincus had now quite recently found that the local dilatation took place only when the stimulation was given during the second half of the systole. At the beginning of the systole, on the other hand, the stimulation had no effect whatever, and during the diastole it even gave rise to local systole. The effects of the local mechanical stimulation lasted some time, and, besides the local contraction or relaxation, manifested itself in a heightening of the diastolic or systolic state on each occasion at the stimulated spot.

Physical Society, April 2.—Prof. du Bois Reymond spoke on the irreciprocal conduction of electricity found by him in the electrical organ of fishes, and discussed the teleological significance of this property for the capability of fishes to discharge strong electrical currents outwardly (NATURE, vol. xxxiii. p. 407).—Following up the address at the last sitting by Dr. Baur, Dr. Pernet spoke on some other more recent thermostats, in particular on those which effected the regulation by means of vapour pressure. In the closed short leg of a manometer was a small quantity of a fluid readily susceptible of evaporation; above it was placed quicksilver, which also filled the long leg of the manometer. The short leg of the manometer with the fluid referred to lay in the bath, the temperature of which should be kept constant. Did the temperature rise above the desired degree, then the quicksilver of the manometer also mounted in consequence of the pressure of the vapour, and the flow of the gas to the flame got thereby in part shut off. The temperature than sank, the vapour condensed, and the quicksilver in the manometer fell. To render the apparatus available at every over-pressure, the manometer was cut through and connected by a movable piece of tube. As the material best adapted for these flexible connections, the speaker recommended thin steel tube, which was coated over with lead, thereby rendering it easily pliable and not liable to any elastic after-effect. The regulation by means of the long manometer tube was accomplished in an electrical way by an electro-magnet. The details of the arrangement of the thermostats in question were illustrated in part by models, in part by drawings. As fluid for very low temperatures, a mixture of two hydrochloric ethers was used; for higher temperatures, a mixture of ether and alcohol; for temperatures above 100° C., water; and for still higher degrees of temperature, other fluids. With respect to the efficacy of these thermostats, the speaker adduced that he was able to keep a water-bath for a considerable length of time constant to within 0°·02 C.—Dr. König laid before the Society a photometer sent to him from Messrs. Yeates and Son, of Dublin, which apparently far surpassed the Bunsen photometer. It consisted of two quadratic prisms of cast paraffin connected with each other on a longitudinal side. Between these two prisms was placed a silver leaf or a tinfoil leaf. When light from one source fell on the one prism, then it appeared clear white on account of the diffused reflexions. The light was able to penetrate to the other only through the metal sheet. The other prism therefore appeared dark. If a second light was placed on the other side, then the other prism appeared likewise bright. By displacement on a scale the photometer could be brought into the position in which both sides appeared equally bright. The distance from each other of the two sources of light gave in that case the relation to each other of the intensities. The speaker proposed some arrangements which would render this photometer available for coloured light as well. Similar proposals for this purpose had already been made by Dr. Jolly.—Dr. König further made some supplementary communications on the case recently discussed by him of anomalous colour-seeing arising from alcoholism. After determining that the occurrence of a neutral point in the spectrum was a perfectly certain proof that the eyes in question perceived only two fundamental colours, he investigated the extension of the colour curves by the employing of mixed colours, and thereby obtained important results, which he promised to communicate to the Society in a complete form in May or June next.

BOOKS AND PAMPHLETS RECEIVED

"Hand-book of Plant Dissection," by Arthur, Barnes and Coulter (Holt, New York).—"Manual of Physical Geography of Australia," by H. B. de la Poer Wall (Robertson, Melbourne).—"Journal of the Chemical Society," May (Van Voorst).—"Papers and Proceedings of the Royal Society of Tasmania for 1885" (Tasmania).—"Journal of the Royal Agricultural Society of England," April (Murray).—"Proceedings of the Bath Natural History and Antiquarian Field Club," No. 1, vol. vi. (Davies, Bath).—"The Topographic Features of Lake Shores," by G. K. Gilbert (Washington).—"Oils and Varnishes," by J. Cameron (Churchill).—"Year-Book of Scientific and Learned Societies, 1886" (Griffin).—"Notes on Analytical Chemistry," 2nd edition (Churchill).—"Mountain Ascents," by J. Barrow (Low).—"Dogs in Disease," 2nd edition, by Ashmont (Low).—"Bulletin de la Société Impériale des Naturalistes de Moscou," Nos. 1 and 2 (Moscou).—"British Petrography," part 4, by J. J. H. Teall (Watson, Birmingham).—"Missionary Work among the Ojibway Indians," by Rev. E. F. Wilson (S.P.C.K.).—"Our Island Continent," by Dr. J. E. Taylor (S.P.C.K.).—"A Manual of the Diseases of the Elephant," by J. H. Steel (Moore Madras).—"A Treatise on Elementary Statics," by J. Greaves (Macmillan).

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