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THURSDAY, MAY 16, 1872

EXAMINATIONS IN TECHNOLOGY

NO subject has been more talked about of late years than Technical Education. No term has been more vaguely or indefinitely used than this, even in education, that region of loose definition; yet it cannot be doubted that at the present time no subject is of more vital importance to this country, to enable it to maintain its manufacturing position, than a general diffusion of sound technical knowledge—a knowledge, that is, which rests on a thorough apprehension of the scientific principles which lie at the root of the various arts and manufacturing processes.

Bacon, in the first of his "General Aphorisms for Interpreting Nature and Extending the Empire of Man over Creation," says:—"Man, who is the servant and interpreter of Nature, can act and understand no further than he has, either in operation or in contemplation, observed of the method and order of Nature." And he proceeds, "neither the hand without instruments, nor the unassisted understanding, can do much; they both require helps, the understanding no less than the hand, to fit them for business. The knowledge and power of man are coincident; for whilst ignorant of causes he can produce no effects, nor is Nature to be conquered but by submission. And that which in speculation stands for the cause, is what in practice stands for the rule." The men of science of our day are not open to Bacon's rebuke to the mathematician, the physician, and the chemist of his day, that they were concerned in the works of Nature, but all of them superficially and to little purpose. Day by day sees them conquering Nature by submission. Are the thousands engaged in our manufacturing industries capable of taking advantage of their conquests? How painfully true with respect to them still are his words, written some 250 years ago, "The works hitherto discovered are owing rather to accident and trial than to the sciences."

Playfair remarks on this, "One of the considerations which appear to have impressed Bacon's mind most forcibly was the vagueness and uncertainty of all the physical speculations existing in his time, and the entire want of connection between the Sciences and the Arts." The vagueness and uncertainty of physical speculation is rapidly clearing away. Is the connection between the Sciences and the Arts as rapidly being cemented? We fear not. The world has become imbued with the truth of Bacon's saying, that "in works men can do no more than put natural bodies together and take them asunder; all the rest is performed by the internal operations of Nature." But how little is the order of Nature which should regulate this putting together and taking asunder understood in our workshops! How much is trusted to trial and error! How little is the store of knowledge accumulated by our men of science drawn upon! How great is the waste of our resources!

We therefore hail with satisfaction a scheme of technological examinations proposed by Captain Donnelly, R.E., which the Society of Arts has adopted on the recommendation of an able committee of scientific and professional men to whom it was referred, and which it appears, from a paper lately issued, the Society intends to carry out if the requisite support be forthcoming.

The proposal of Captain Donnelly is briefly that every year the Society of Arts should arrange for the examination in the science and technology of certain arts and manufactures. A committee qualified to advise on the subject is to prepare a syllabus of the examination in each branch of industry. It is an instruction to them "that it is essential that the candidate should possess, on the one hand, such an elementary knowledge, at least of science, as will prove that he understands the scientific principles of which his art is an application; and, on the other hand, such a knowledge of the application of those principles in his trade, as will show that he is practically conversant with the various processes and manipulations of the factory or workshop. The theoretical knowledge must not be a mere 'cram' of empirical dicta, nor the practical knowledge a mere committal to memory of descriptions of manufactures picked up from text-books." This instruction shows that the technology which it is proposed to cultivate by means of these examinations is thoroughly sound.

The requirements from a candidate fall naturally under three heads. We have first those branches of abstract science which are involved in the special industry under consideration; secondly, the special applications of those abstract or general sciences to that industry; and lastly, a practical knowledge of the machinery, processes, and manipulation.

The examinations of the Science and Art Department, which are now held pretty generally in all parts of the kingdom, and which can be extended to any place which desires to avail itself of them, by the simple process of forming a local committee of superintendence, provide the ready means of testing the candidates' knowledge of any branches of general science. It is only necessary then to determine what branches of science are the foundation of the technology of any industry, and to specify the examination which the candidate shall pass for each grade of certificate. The Society of Arts, working in concert with the Science and Art Department, proposes to avail itself therefore of these examinations to determine the candidate's knowledge of pure science.

As respects the technology or special applications of general science, the committee will prepare a syllabus for each industry. And the examination in these matters will also be conducted by means of the local committees after the general science examinations, the papers of questions being prepared by special examiners, to whom the answers will be submitted. Finally, the candidate's practical knowledge will be ascertained by a return of his employment in the factory or workshop, giving his rate of wages, &c., certified by his employer, somewhat in the form of the return required from candidates for Whitworth Scholarships. No more reliable criterion of a candidate's practical knowledge could be afforded than this. It is in the workshop, and in the workshop alone, that a true practical education can be obtained. It is a great advantage that this scheme wholly avoids running counter to the just susceptibilities of our manufacturers on this cardinal doctrine, and proposes simply to strengthen and ennoble this practical education by combining it with sound scientific instruction. The whole machinery of the examination is simple, effective, and, by means of local co-operation—a machinery which already exists—readily applicable, at small cost, to all parts of the kingdom.

The examinations are to be adapted to three grades of certificates: an elementary, or "Workman's" certificate; an advanced, or "Foreman's" certificate; and an honours, or "Manager's" certificate.

No syllabus has yet been issued, but we have seen the syllabus for paper manufacture, which, though not finally adopted by the committee, is in a forward state. How many candidates will come up to the mark? We fear but few. There is no use shutting our eyes to the fact. Among manufacturers how many are there who could pass a fair examination in the Science and Technology of their trade? And yet the committee have not pitched their standard too high. One great benefit—if no other—will be conferred by these committees. They will show at least what ought to be known.

As a commencement, Captain Donnelly proposes that those industries should be taken for examination which form the subjects of the Annual International Exhibitions, and that the Royal Commissioners for the Exhibition of 1851 should be asked to provide the requisite funds. The committee endorse Captain Donnelly's view, and think that the Council of the Society of Arts "may find it advantageous to include those Arts and Manufactures." We trust that it may be found practicable to include annually many more, and that this important movement will not be left to depend on the Annual Exhibitions alone, however ready the Commissioners may be to support it. It is for the manufacturers of this ountry, for the City Companies, and the large towns, whose very existence depends on their manufacturing supremacy, to come forward and aid this important work, and do for their several industries what Sir Joseph Whitworth has done for mechanical engineering by his noble endowment.

By this means a stimulus will be given to the extension of scientific instruction; an aim and organisation afforded of which it stands in much need; and a decided step taken to re-establish our manufacturing supremacy, which, in consequence of the superior educational position of our continental rivals, is now trembling in the balance.

WATTS'S DICTIONARY OF CHEMISTRY

A Dictionary of Chemistry. By Henry Watts, F.R.S., B.A., &c. *Supplement.* (Longmans, Green, and Co., London, 1872.)

ENGLISH chemists will hail with gladness the appearance of the supplemental volume to "Watts's Dictionary." It was evident almost before the completion of the last volume of the original work, that a supplementary volume would be required very shortly. In these days of progress chemical books are quickly left behind, and it needs energetic measures for our literature to keep pace with fresh chemical discoveries. Chemistry has much to be thankful for at the hands of Mr. Watts. The present volume brings up our knowledge to the end of 1869, and also includes several additions, corrections, &c., which have appeared in 1870 and 1871. The scope of this volume is, as in former volumes, sufficiently wide; the contents are not entirely confined to chemistry, but include articles on electricity, heat, light, &c. The connection between these subjects and chemistry is so close that no book would be perfect which did not enter into and explain some of the effects caused by these forces. The plan of "Watts's Dictionary" is too well known to require any comment. The present volume is strictly a continuation of the former ones; and, as time rolls on, other supplemental volumes will be required to make this record of chemical history complete. As it is, we now possess in "Watts's Dictionary" a complete account of chemical discovery up to the end of 1869; and in the abstracts of foreign papers published by the Chemical Society we have a contemporaneous record of all new facts, beginning, however, with the year 1871. It is, perhaps, unfortunate either that Mr. Watts did not bring out his Supplement one year later, or that the Chemical Society did not commence their extremely valuable work one year earlier. At the present time, therefore, we have one year to a certain extent unrepresented. We have, however, gained a great step; instead of having to wait two or three years for the appearance of the "Jahresbericht," we have now the abstracts of foreign papers a month or so after their publication. It is worthy of remark that Mr. Watts's dictionary has outstripped the "Jahresbericht," the third volume of which, for 1869, has not yet appeared. The author has fortunately succeeded in obtaining the assistance of some of the former contributors to his work, thus Prof. C. G. Foster contributes two very clear articles on recent discoveries in electricity and heat, whilst Prof. Roscoe has written the articles on "Light and on Spectrum Analysis," which give a very excellent *résumé* of the work done in these branches of science, and which, perhaps, might have been lengthened with advantage. The article on "Proteids" is written by Prof. M. Foster, whose name is a sufficient guarantee for its excellence. Dr. Paul and Mr. Wanklyn have also contributed to the Supplement, the latter having written on acetic ether (in part), on butyl alcohols, &c. The only possible objection to this outside help is that, in some instances, undue prominence may be given to certain of the author's theories or remarks, to the comparative overlooking or slighting of the work of other chemists. We must not, however, omit to speak in the highest terms of many of the articles contributed by Mr. Watts himself, such as the extremely clear and succinct account of the aromatic series as explained by Kékulé's hypothesis, the article "On Atomicity," and many others too numerous to mention. We cannot give the volume greater praise than by saying it is quite equal to the former productions of the author. Since the publication of the last volume, the chemistry of the aromatic series seems to have usurped the principal attention of chemists, as we find by long articles on benzine, on its derivatives and homologues, no less than forty-five pages being thus occupied; then again the substitution derivatives of benzoic acid and of phenol occupy a considerable space. Another subject which seems to have attracted a considerable amount of attention, and to have yielded very interesting results, is that of the alcohol cyanides and nitriles. An article on inorganic analysis, by Bunsen's flame reactions, will be found of great interest, and will repay a considerable study. In fact, the whole volume is most complete, and must be looked on with great satisfaction. A. P.

OUR BOOK SHELF

Index der Petrographie und Stratigraphie der Schweiz und ihrer Umgebungen. Von B. Studer, Professor der Geologie. Pp. 272. (Bern: K. Schmid. London: Williams and Norgate)

TWENTY years having elapsed since the publication of the "Geologie der Schweiz," Prof. Studer thinks that some new account of the geology of his country cannot be deemed superfluous. Since the date of that work numerous separate volumes, papers, maps, &c., relating to the geology of Switzerland have appeared. Many of these, however, are difficult of access, and not a few have been to all intents and purposes lost sight of. As a consequence of this, it is exceedingly difficult or even impossible for the student of Swiss geology to find out what has been written. This is easily understood when we remember that Switzerland has been a favourite field of study with geologists of all nations, and that descriptions of her rock-masses and formations are to be met with in the publications of almost every scientific society in Europe. Prof. Studer complains, and not without reason, that many of the names of rock-divisions and formations are derived from little obscure outlying places, for which we look in vain on the best maps, or from fossils which are familiar to only a few adepts, and that the same rock or formation, as the case may be, is known by different names in different regions, thus giving rise in the student's mind to confusion worse confounded. This index (the preparation of which must have cost its author a world of labour) will smooth the way to learners, and will, we are persuaded, be of scarcely less value to professors themselves. Petrological and stratigraphical synonyms are clearly explained, and the equivalents of the Swiss rocks met with in adjoining countries are given. The index is arranged alphabetically, and the list of "articles" leaves nothing to be desired. The descriptions are short, clear, concise, and at the same time comprehensive, those which relate specially to Swiss geology being of course the fullest. The author modestly says that his index makes no pretensions to be a text-book, and refers his readers for greater details to the works of Naumann, Zirkel, Senft, Cotta, &c.; yet we think that the very absence of minute details will be one of its chief recommendations to the geologist, who can always turn to the text-books and other sources when he feels inclined, for the index literally bristles with references. A long list of localities is added, by consulting which we are referred to the various articles in which they are mentioned. Thus, with a good map and Prof. Studer's index before him, one may gather a very clear conception of Swiss geology. The book is not bulky, and will be an invaluable companion to any geologist who thinks of trying his hammer in the "playground of Europe." J. G.

On the Early Stages of an Ascidian (Cynthia pyriformis). By Edward S. Morse, Ph.D. (Boston: 1871.)

IN this communication, reprinted from the Proceedings of the Boston Society of Natural History, Dr. Morse gives an account of his examination of the tadpole-like larva of a sessile Tunicate at Eastport, Maine, in July 1870. He confirms the statements of Kowalewsky and Kupffer, and describes "a remarkable structure in the caudal fin, which vividly recalled the fine diverging rays seen in the embryo fish. These rays were exceedingly delicate, though plainly marked. They ran off nearly parallel to the longitudinal axis of the tail, and were confined to the last five segments." This observation, if confirmed, will be of importance; it points rather to general piscine affinities in the Tunicata than to their special connection with *Amphioxus*. We are glad to see that Dr. Morse is alive to the danger of mistaking the effects of preserving fluids for natural appearances in microscopic specimens. Some neat figures illustrate the paper, which we hope is only the beginning of more complete investigation of this deeply interesting subject by the writer.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. No notice is taken of anonymous communications.*]

Magnetism in Copper Slags

ON examining the magnetic properties of some ores and minerals, I observed that a specimen of ore furnace slag from copper smelting was strongly polar magnetic.

Being surprised at this phenomenon, I mentioned it to Dr. Percy, Professor of Metallurgy at the Royal School of Mines, who kindly gave me permission to examine some of his slags, and also some of those exhibited in the Geological Museum.

I examined several specimens of ore furnace slags, and found they were all more or less magnetic and strongly polar; this even extended to some very small pieces the size of a pea. Most of these were of the ordinary kind, and of a porphyritic appearance, from the pieces of white quartz imbedded in their mass.

One specimen was of a vitreous character. This was not so strongly magnetic as the ordinary kind.

Metal slags from the second fusion.—Those examined were polar magnetic. They were Museum specimens, beautifully crystallised; the magnetic properties were distinct throughout the mass, though more feeble than in the ore slags.

Roaster slags from the third fusion.—I examined two specimens of this class; both were polar magnetic, but the magnetism was confined to a few points, and was not developed in the whole mass, resembling the consequent points in magnetism.

Refinery slags.—I examined one specimen; it was very feebly magnetic, though not polar, and the magnetism was confined to a few points in the mass.

In the analysis of copper slags, the iron present is always estimated as protoxide in combination with silica, forming a silicate of protoxide of iron. Unless this silicate is magnetic, it is difficult to understand how the whole of the iron is thus combined. Further analysis must decide this point.

EDMUND F. MONDY

The Volcanoes of Central France

GEOLOGISTS state that the volcanoes of Auvergne have not been in action in historic times (see Lyell, last ed., p. 479; also Jukes and Geikie, p. 354). I find, however, that the Rogation Days were appointed by Mamercus, Bishop of Vienne, in Gaul, about A.D. 460, for the purpose of chanting litanies to stay the volcanic eruptions which were then devastating his diocese (see Robertson's "Hist. Ch. Church," 4th ed., vol. i. p. 589; also "Proctor on Book of Common Prayer," note, page 251.)

Youghal, Co. Cork, May 13 W. J. GREEN

The Eruption of Vesuvius in 1855

IT has occurred to me that, at the present moment, the subjoined extract from the travelling notes of my husband, the late Dr. Marshall Hall, might be thought worthy of insertion in your valuable periodical. We happened to be at Naples when the eruption of Vesuvius in May 1855 occurred, of which the following gives some description:—

"During five years Vesuvius had remained in a state of inactivity, when, on May 1, 1855, indications of an eruption manifested themselves.

"Early on the morning of the 1st smoke and fire appeared, occupying a point on the north-west side of the mountain, and red-hot lava began to flow down the Atrio del Cavallo.

"On May 2 we all left our hotel at a quarter-past 5 P.M. for Vesuvius, driving up to the Hermiage, and then walking about a mile to the incandescent stream.

"The distant view presented a zig-zag line of fire. As we approached we saw the movement of this stream of lava; in some points solid masses were turned over and moved downwards; in others, bright points occurred where some tree or other combustible was inflamed. Nothing could be more splendid. It was a river of fire from fifty to one hundred yards in breadth.

"We had seen the Falls of Niagara and the glaciers of the Alps, all of a stupendous beauty; but this was sublime and fearful.

"The lava on which we stood, near this stream was warm and on raising a portion the substratum was red-hot. Was it quite safe to be there?

"The view was magnificent, and our position possessed quite sufficient of the fearful to make it sublime: a scene of moving molten masses of liquid fire.

"The stream issued, not from the summit of the mountain, as heretofore, but from its north-western side, on which seven apertures existed. From the highest of these a burst of fire took place upwards from time to time.

"The stream seems to issue in a viscid half-liquid state, whilst its surface, and especially its edges, cold by contact with the atmosphere, become solid, forming a channel and floating or rolling masses. The lava remains long incandescent, even when it has become solid, being a bad conductor of heat. On the same principle the masses of consolidated lava are formed in minor masses, giving to the general mass of surface the most irregular forms, frequently with sharp and prominent edges and projections. Even when these masses are the smallest, it is difficult and even dangerous to walk upon them.

"On Saturday, May 5, I ascended to the summit with Dr. Bishop and my son. From the great crater at the summit there issued much smoke, consisting chiefly of sulphurous acid gas. This proved extremely irritating to the nostrils and bronchia, inducing sneezing and coughing. Three openings existed near together along the edge of the crater at the very summit, which emitted a similar vapour. At points considerably lower, three larger openings were formed on the north side of the cone, from which immense quantities of smoke issued, mingled with fire, differing somewhat in colour, and depositing sulphur of a light green, orange, and bright yellow colour. At a distance the green sulphur, spread over ancient lava, was mistaken, even by our guide, for vegetation, but proved to be sulphur on a nearer examination.

"Below the third of these larger openings there was a cascade of red-hot lava from the edge of a precipice, of immense dimensions, presenting a sublime fall of liquid fire.

"Along this part of the cone masses of stone continually rolled down the slope, dislodged by the movement of the cone (for none were ejected), which some of our party felt distinctly.

"Below the fall the lava proceeded in a continuous stream, consisting partly of flowing, partly of rolling masses, pursuing an irregular course downwards in the Atrio del Cavallo, in one place dividing into two, in others taking a zig-zag turn. From its surface a dense smoke arose generally, but in some places the existence and combustion of a tree gave a bright blaze of light.

"The surface of some parts of the lava stream had already cooled and consolidated sufficiently to admit of our walking over it. This surface was crisp and wave-like, and in some parts sounded hollow when struck with our staffs.

"We picked up one specimen of porous lava, in a crevice of which a fly of considerable size was imprisoned, a miniature picture of Herculaneum or Pompeii. Our boots were torn to tatters." CHARLOTTE HALL

Brighton, May 10

Earthquakes and Permanent Magnets

IN a notice by Dr. A. B. Meyer in No. 116, vol. v. of NATURE, respecting earthquakes in the Island of Celebes, he states that the often-repeated story of the keepers of permanent magnets detaching themselves, and falling at the moment of an earthquake shock, was never verified in his experience. If I remember rightly, this peculiar action was first mentioned by a Frenchman living on the west coast of South America, and much doubted by many at the time. It is not likely that there is any difference between the effect of an American and an Asiatic earthquake on the magnet, if any such exists; but I must state, in corroboration of Dr. Meyer's note, that I have had a permanent magnet and keeper suspended in my study for many years, expressly for the purpose of testing this matter, and on no occasion of an earthquake has the keeper fallen from the magnet, not even in the terrific earthquake of 1863, which was so destructive to the city of Manila and the neighbouring provinces.

The terrestrial disturbances still continue in the Philippines, and almost every post brings us intelligence of earthquakes in the provinces. More has occurred lately: an eruption of the Mayou, a magnificient volcano in the province of Albay, unaccompanied, however, by any serious disasters. As I have already mentioned in my notice of the new volcano which suddenly broke out in the island of Camiguin,* the past year has been remarkable for the great number of earthquakes throughout the Archipelago, especially in the great island of Mindanao, where the new military colony on the great river suffered greatly.

Manila W. W. WOOD

The Australian Eclipse Expedition

IN your number of NATURE for December 7, 1871, it is stated, in regard to the Eclipse Expedition, that "notwithstanding the supineness displayed by the other Australian colonies, it was still hoped that the Government of Victoria would render such pecuniary assistance as would make it possible for the Expedition to set out with some chance of success in obtaining results of scientific value."

Now, while giving all honour to the Royal Society of Victoria for originating and carrying out the expedition, it is only bare justice to the colonies of New South Wales and Queensland to state that, but for the liberal way in which they responded to the cause of science, there would have been no Eclipse Expedition here. No steamer could be obtained in Victoria within the means of the Royal Society, and, at the instance of the Government of New South Wales, who were moved by their astronomer, the Government of Queensland lent a steamer and contributed 115*l.* in money; while the Government of New South Wales contributed 330*l.* to the funds of the Royal Society of Victoria for the Eclipse Expedition, and upwards of 130*l.* towards the expense of steamer and their own observing party, besides sending Lieut. Gowlland, without whose aid in navigating the ship in those dangerous waters, the ship would not have been lent, and there would have been no Expedition here.

A SYDNEY MEMBER OF THE ECLIPSE EXPEDITION

Sydney, March 25

*** Our information was derived from correspondents in Australia. We gladly notify the correction, and give the Governments of Queensland and New South Wales their due.—ED. NATURE.

Waterspouts in the Fen-land

THE letter of Mr. Gray on a waterspout observed by him on the river Ebwy, which appeared in your number for April 25, vividly recalled a similar case which has come under my notice in the Fen-land.

During the summer of 1870, while in Deeping Fen on a day when the wind was blowing in gusts, carrying the dry powdery peat-dust in clouds before it, I observed a whirling column of dust advancing towards me. It was like those smaller pillars so frequently seen in the streets of a town on such a day, but was considerably larger, being from 15 to 20 feet in height. When it was first seen it was advancing from the far side of a *ground*, as the unenclosed fields are called, towards me at the rate of about six miles an hour, and was distant some five hundred yards. It moved with an unsteady staggering motion, accompanied with a rushing noise. I stayed to watch it cross a dyke about 15 feet wide, which ran directly across its path. The smaller dykes it seemed to cross without affecting them, but on reaching the one in question it whisked the water up into a waterspout some 10 feet high with a gurgling hissing sound, and steering directly across the dyke burst on reaching the opposite shore, projecting a considerable quantity of water upon the land. This effort seemed to spend its force, for the dust-column resumed on the opposite

* In some accounts of this phenomenon, the island of Camiguin on the coast of Mindanao, has been confounded with another island of the same name in the Bataanes, to the north of Luzon.

land was but small in proportion, and after swaying about for a few yards, died away.

I have been informed of similar cases in this district, but the above is the only instance in which I observed a waterspout myself. SYDNEY B. J. SKERTCHLY

H.M. Geological Survey, Wisbech, May 2.

The Geologists' Association at Watford

IN the notice in your last number of the excursion of the Geologists' Association to Watford there is a slight error which perhaps I may be permitted to correct.

The sections of the Woolwich and Reading Series which were examined are at Watford Heath Kiln and at Bushey Kiln (*not* Bushey Heath), and the formation, although varying very much in the short distance (scarcely a mile) that these places are apart, is at each place represented by beds of clay, sand, and pebbles. The pebble beds are, however, better seen at the latter than at the former place. JOHN HOPKINSON

Temperature of Hill and Valley

IN NATURE of May 2, page 19, there is an interesting report of a paper by Mr. Dines "On the Temperature of Hill and Valley," showing that (to use Mr. Gaster's words in the discussion) "the air is colder on the top of the hill than in the valley, by day, when the sun is shining, and warmer at night when it is not shining." This appears anomalous at first sight, but I believe it has long been known, and it is easily exp'ained. The temperature of the hill top is not produced where it is observed. As Mr. Glaisher stated in the same discussion, the higher we go in a ba'loon the less is the range of temperature; and the temperature at the top of a hill which is at all isolated, or even steep on one side, approximates to that observed in a balloon at the same absolute height.

The reason why temperature has a less range in the higher atmospheric strata, is that the earth has very much more power of both absorbing and radiating heat than the molecules of air, and consequently heats more rapidly in the daytime and cools more rapidly at night. The temperature of air at the surface of the earth is determined much more by the absorption and radiation of the earth than by its own.

The truth of this view is shown by the fact that the law is quite different for table-lands from that which we have seen to be true for isolated hills. On table-lands the diurnal range of temperature is greater than on low plains, though on isolated hills it is less. These facts appear to show that while, other conditions being given, the mean temperature of a station chiefly depends on its height above the sea level (or, in other words, the thickness of the atmosphere above it) the diurnal range at the station (whether hill top or balloon) chiefly depends on the proximity of the atmospheric stratum surrounding it to the surface of the earth.

The fact stated in the same paper that "in cold weather the air on the top of the hill is never so cold as that in the valley," is no doubt partly due to the cause above stated, but partly also, I think, to the fact that cold air is heavier than warm, and seeks the lowest position. I believe there is no doubt this is the explanation of the *glacières* or freezing caverns of the Jura described in the Rev. Harold Browne's book.

JOSEPH JOHN MURPHY

Old Forge, Dunmurry, Co. Antrim, May 8

Meteors

I OBSERVED a meteor at about half-past eleven on the night of the 8th inst., in the constellation Scorpio, which passed very close to the star Antares, travelling from right to left.

It appears to me worth remarking from the fact of its course lying very near, and roughly parallel to, that part of the ecliptic which corresponded to the earth's position in her orbit.

It traversed some eight or ten degrees of arc, and was visible for three or four seconds, gradually increasing in brightness till it was nearly on a par with Antares, which star it also resembled in colour. Its slow apparent motion immediately suggested the idea that it was moving in the same plane and direction as the earth; in fact, that it was overtaking us in an orbit just outside our own.

The course of another meteor, seen about half an hour earlier from a westerly window, and described to me as not very inferior to Jupiter, appears also to have lain in the direction of the ecliptic, but from left to right, in the neighbourhood of the constellations Gemini, Cancer, or Leo.

It is rash to generalise from such insufficient data, but I conceive these meteors may both have belonged to a system whose orbit lies nearly in the plane of the earth's; the apparent retrograde motion of the last-named being caused by the direction of its path crossing our orbit at a point behind the earth's then place instead of in advance of it.

Cardiff, May 10 GEO. C. THOMPSON

The Ivory Crayfish

I THINK it may be interesting to some of the readers of NATURE to know that a specimen of the "Ivory crayfish," or *Astacus (Cambarus) pellucidus*, mentioned in the very interesting communication of Dr. Packard on the Mammoth Cave of Kentucky in NATURE, April 18, has been living in the aquarium-house in the Regent's Park for a considerable time. The specimen was brought over at the close of the last year by Mr. Boyd from the Mammoth Cave; it is now placed in the first fresh-water tank on the right hand of the visitor as he enters the aquarium. Its dark-loving habits do not permit it to be seen much, as it generally burrows partially under a large stone, from beneath which only the tips of its white claws can be seen.

Culverlea, Winchester, May 8 W. A. FORBES

THE AMERICAN ACADEMY OF SCIENCES

THE Annual Meeting of the National Academy of Sciences was convened, on the 16th of April last, at the Smithsonian Institution in Washington. The existence of this body was authorised by an Act of Congress passed in 1863; and it was originally limited to fifty members, designed to represent the most eminent men of science in the country, who were to be organised for the purpose of serving as advisers to the United States Government in questions of a scientific nature. The Academy has rendered excellent service in this capacity, and has had referred to it very many important questions, the satisfactory solutions of which have saved much money to the Government, and increased the efficiency of many of its bureaus. One condition of membership is that all such service to the Government is to be performed without charge.

As this Society, by its national character, takes the lead of State Institutions for a similar object, and the number of members was at first limited, considerable dissatisfaction was felt by many persons who believed themselves worthy of membership, but were excluded by this restriction. The Academy, therefore, after mature deliberation, decided to ask Congress to remove the limitation as to number, which being done, the principal business of the Academy at its late meeting consisted in the increase of its force. Twenty-five new members were selected, representing the various branches of theoretical and applied science, and the number is to be increased by five each succeeding year. Very few papers or communications were presented to the Academy, as all the time of the meeting was required in carrying out the changes involved by the alteration of the charter, including the formation of a new constitution and rules for its government.

The following is the list of members elected :—Prof. C. A. Young, Dartmouth; Prof. E. D. Cope, Philadelphia; Prof. J. Lawrence Smith, Louisville; W. S. Sullivant, Columbus; Prof. W. B. Rogers, Boston; J. H. Trumbull Hartford; Prof. J. P. Cooke, Cambridge; Dr. A. S Packard, jun., Salem; Prof. W. P. Trowbridge, New Haven; J. E. Oliver, Massachusetts; Prof. E. W. Hilgard, Oxford, Maine; Prof. R. Pumpelly, State Geologist, Missouri; Prof. J. H. Lane, Coast Survey; Prof. A. E. Verrill, New Haven; Dr. J. W. Crafts; Theodore Lyman, Boston; Prof. A. M. Mayer, Stevens Institute, Hoboken; Prof. H. J. Clarke, Amherst; J. Ericsson; Prof. Hadley, New Haven; Dr. F. A. Genth, Philadelphia; Charles A. Schott, Coast Survey; Prof. A. H. Worthen, State Geologist, Illinois; Captain J. B. Eads, St. Louis; General H. L. Abbott, U.S.A.

NATURAL SCIENCE SCHOLARSHIPS AT OXFORD

FOR WHICH ELECTIONS WILL BE MADE DURING THE YEAR 1872

BALLIOL COLLEGE.—One Scholarship, value 70*l.* per annum, and tenable for three years, is generally given. There are two such Natural Science Scholarships on the foundation of Miss Brakenbury, and a third is usually added by the College. Papers are set in Physics, Chemistry, and Biology; the Examination in Chemistry and Biology will be partly practical if necessary. Candidates, if Members of the University, must not have exceeded eight Terms from their Matriculation. The Examination takes place in November.

CHRIST CRURCH.—Not less than one Studentship, of the annual value of 75*l.*, together with rooms rent free, and tenable for five years from the day of Election. The subjects of Examination are Physics, Chemistry, and Biology; but no Candidate is expected to offer himself for examination in more than two of the three. Candidates must not have exceeded the age of twenty on the 1st of January preceding the election. The Examination is held in the middle of February.

JESUS COLLEGE.—One open Scholarship, value 80*l.* per annum, is occasionally given. It is tenable to the close of the twentieth Term from the Scholar's Matriculation. Papers are set in Chemistry, Physics, and Biology; but answers are not expected in more than two subjects. Candidates will have to satisfy the Electors of their ability to pass the ordinary Classical Examinations required by the University. Candidates must not on the day of Election be full twenty-four years old. The Examination takes place in October, and full notice is given early in June. Two Scholarships have been given.

MAGDALEN COLLEGE.—One or more Demyships, value 95*l.* per annum, inclusive of all allowances, and tenable for five years, provided that the holder does not accept any appointment which will, in the judgment of the Electors, interfere with the completion of his University Studies. No person will be eligible who shall have attained the age of twenty years. In conducting the Examination, Questions will be put relating to General Physics, to Chemistry, and to Biology, including Human and Comparative Anatomy and Physiology, with the principles of the classification and distribution of Plants and Animals; but a clear and exact knowledge of the principles of any one of the above-mentioned Sciences will be preferred to a more general and less accurate acquaintance with more than one. The Examination in Biology and Chemistry will be partly practical, if necessary. Candidates have also to satisfy the Electors of their ability to pass the ordinary Classical Examinations required by the University, and for this purpose will have:—*a.* To translate a passage of English Prose into Latin. *b.* To bring up for Examination one Greek author, or a portion, such as five books of Homer, or two Greek Plays, or any equivalent; one Latin author, or a portion, such as the Georgics, or five books of the Æneid of Virgil, or three books of the Odes and the De Arte Poetica of Horace, or any other equivalent. *c.* To answer Questions in Greek and Latin Grammar. Very superior excellence, however, in Natural Science will be allowed to compensate for any deficiency which Candates may have shown in the Classical part of the Examination. Candidates will be required to bring with them a Certificate of Birth, with testimonials of good conduct and character, extending over a period of at least three years, from the Head Master of their School, or from the Private Tutor with whom they may have been reading. The Demyships are open without any restriction as to place of Birth or Education to all Candidates, whether already Members of the University or not, who are found to satisfy the above-named conditions. The Examination will be held in common with Merton College, at the same time and with the same Papers. Each Candidate will be considered as standing, in the first instance, at the College at which he has put down his name, and, unless he has then given notice to the contrary, will be regarded as standing at the other College also. The Examination usually commences on the first Tuesday in October. No Entrance Fees or Caution Money are required by the College. The University Fees payable on Matriculation amount to 2*l.* 10*s.*

MERTON COLLEGE.—One Postmastership, value 80*l.* per annum, tenable for five years, or so long as the holder does not accept any appointment incompatible with the full pursuance of the University studies. Papers will be set in Chemistry, Physics, and Biology; and an opportunity will be given of showing a knowledge of practical work in Chemistry and Biology. The Postmastership will be given for special excellence in one subject, or for excellence in two of the three subjects; but no Candidate will be examined in more than two subjects. There is no limit of age for the Candidates, but a limit of six Terms of University standing. The Examination will be held in common with Magdalen College at the same time, and with the same Papers. Each Candidate will be considered as standing, in the first instance, at the College at which he has put down his name, and, unless he has given notice to the contrary, will be regarded as standing at the other College also.

NEW COLLEGE.—Candidates for Exhibitions may offer to be examined in Natural Science, in addition to the Classical Examination, or in lieu thereof. There is no restriction of age, but no Candidate must have already entered on residence in another College or Hall. The Examination usually takes place in March.

UNIVERSITY SCHOLARSHIP.—*Burdett-Coutts Scholarship.*—One Scholar is elected every year in Lent Term. Candidates must have passed all the Examinations necessary for the Degree of B.A., and not have exceeded the twenty-seventh Term from their Matriculation. The Examination is in Geology, and in Chemistry and Biology as bearing on Geology.—*Radcliffe's Travelling Fellowship.*—One Fellowship, value 200*l.* per annum, and tenable for three years, is filled up each year in Lent Term. For conditions of Examination and Election, see "The Oxford University Calendar."

A LECTURE ON THOMSON'S GALVANOMETER

DELIVERED TO A SINGLE PUPIL IN AN ALCOVE WITH DRAWN CURTAINS

THE lamp-light falls on blackened walls,
And streams through narrow perforations;
The long beam trails o'er pasteboard scales,
With slow-decaying oscillations.
Flow, current! flow! set the quick light-spot flying!
Flow, current! answer, light-spot! flashing, quivering, dying.

O look! how queer! how thin and clear,
And thinner, clearer, sharper growing,
This gliding fire, with central wire
The fine degrees distinctly showing.
Swing, magnet! swing! advancing and receding;
Swing, magnet! answer, dearest, what's your final reading?

O love! you fail to read the scale
Correct to tenths of a division;
To mirror heaven those eyes were given,
And not for methods of precision.
Break, contact! break! set the free light-spot flying!
Break, contact! rest thee, magnet! swinging, creeping, dying.

$\frac{dp}{dt}$

ON MEASURING TEMPERATURES BY ELECTRICITY*

THE truth revealed to us by one of the younger branches of physical science, which has been cultivated and expounded nowhere more effectually than within these walls, has divested heat and electricity of their mysterious character, and has taught us to regard them simply as "modes of motion."

Light also has been shown to be identical in its nature with heat, and the only remaining physical agency, "chemical affinity," has been recognised as a force differing only in "quality of action" from the others. According to these views, force, in whichever type of action it presents itself, is as indestructible as matter itself, and is therefore capable of being stored up and measured with the same certainty of result. We have a unit of force, or the foot lb., and a unit of heat, or the heat necessary to raise the temperature of 1 lb. of water through 1° Fah., and it has been already proved that 772 units of force are the equivalent value of one unit of heat. Again, the chemical force residing in 1 lb. of pure coal is equal to about 14,000 heat units, or $14{,}000 \times 772 = 10{,}808{,}000$ ft. lbs. = 4,825 tons lifted one foot high.

Questions regarding the quantitative effects of heat present themselves, however, much less frequently for our consideration than questions regarding its intensity, upon which depends the nature of the phenomena surrounding us at every step, both in science and in ordinary life. The instrument at our command for determining moderate intensities or temperatures, the mercury thermometer, leaves little to be desired for ordinary use; but when we ascend in the scale of intensity, we soon approach a point when mercury boils, and from that point upward we are left without a reliable guide. The result is that we find in scientific books on chemical processes statements to the effect that such or such reaction takes place at a dull red heat, such another at a bright red, a cherry red, a blood red, or a white heat—expressions which remind one rather of the days of alchemy than of chemical science of the present day.

There are pyrometers, it is true, but these are either of a complex nature, or little reliance can be placed on them.

It is my purpose this evening to place before you an instrument by which I hope to fill up to some extent the existing gap. It is the result of occasional experimental research, spread over several years, and it aims at the accomplishment of a double purpose, that of measuring high temperatures, and of measuring with accuracy the temperatures of inaccessible or distant places.

But before entering upon the details of my subject, I propose to place before you an instrument which fulfils, in principle, all the conditions essentially necessary in thermometry, and is at the same time the very first instrument that was ever proposed for measuring temperatures. I speak of the air thermometer by Galileo. It can be shown on theoretical grounds that the expansion of a permanent gas at constant pressure is the most perfect index of temperature. It is, in fact, the degree of energy of the atomical motion in an elastic fluid which determines its volume, and which constitutes at the same time its temperature.

The air thermometer consists simply of a bulb of glass with a long tubular stem, open to the atmosphere at its extremity. If I heat the bulb (by dipping it, for instance, into boiling water) and put it into a holder, with the hollow stem reaching downward into a cup of mercury, the air within the bulb will no longer communicate directly with the atmosphere, because the mercury is interposed. If now I cool the air within the bulb, by the external application of iced water, its heat motion will diminish, and its volume would be reduced proportionally, if the external atmosphere could enter freely to fill up the vacancy thus created. But inasmuch as the external air cannot enter, a reduction of pressure will take place, which, according to the law of elasticity by Boyle, must be proportionate to the reduction of volume at constant pressure. The difference of pressure thus created between the bulb and the external atmosphere will be balanced by the column of mercury rising up into the tube, and the elevation to which the mercury attains is a true index of the temperature to which the air in the bulb had been previously heated. This is true with regard to all temperatures, from the lowest to the highest, and the instrument may be termed a universal thermometer. If the bulb could be cooled down to 273° Centigrade below the zero point, it would follow by the law of Charles that the elastic pressure of air would be reduced to nothing, that is to say, the motion of the particles of air, which we call heat, would have ceased, and we should have reached the point of an absolute zero, a point which has been theoretically established also by other means.

Practically, such an instrument would be most inconvenient; its indications would have to be corrected by calculation for barometrical variations; the capacity of the descending tube, which contains air not subjected to variation of temperature, would have to be taken into account, and no reliable observations could be arrived at, without taking special precautions, such as are only within reach of the experimental physicist.

[The other known methods of measuring ordinary and furnace temperatures were here passed in review, and the limits of their application pointed out. They were classified into—

- Thermometers, by expansion of liquids.
- Thermometers, by the expansion of solids.
- Pyrometers, by chemical decomposition of solids, comprising Wedgwood's and Deville's pyrometers.
- Pyrometers, by observing the melting-point of metals.
- Pyrometers, by thermo-electricity.
- Pyrometers, by exposing a copper or platinum ball of known heat capacity to the heat to be ascertained, and of quenching it in a measured quantity of water.]

The instrument which forms the subject matter of my discourse presents many points of analogy with the air thermometer, if we substitute "electrical resistance in conductors" for "expansion of gases." Both these effects are functions of temperature, increasing with the temperature according to progressive laws, which in the case of the gases we call the law of Charles, and in the case of conductors, the law of "increase of electrical resistance with temperature." The latter law, which is of recent origin, had already been partially developed by Arndsen, Swanberg, Lenz, and Werner Siemens, when my attention was directed in 1860 towards an application of the same to the measurement of temperatures at places inaccessible to the ordinary thermometer. By means of the contrivance which I shall describe presently, I was enabled to tell, in the testing cabin of a cable ship, the increasing temperature of the interior of the mass cable in the hold, and to prove the necessity of trans-shipment of the same into a vessel fitted with water-tight tanks, which have been resorted to ever since, to avoid the danger of softening the gutta-percha covering.

I have arranged an apparatus for proving to you in the first instance that the conductivity of a wire of platinum or other metal is greatly influenced by its temperature; for this purpose I direct the current of a galvanic battery at will through two branches of equal resistance, each branch comprising a free spiral wire of platinum and one of the coils of a differential galvanometer. By throwing the powerful light of an electric lamp upon the face of the differential galvanometer, and by throwing the image by means of a mirror and lens upon the screen, the audience will see any movement of the needle to the right or the left that

* Lecture delivered at the Royal Institution of Great Britain, March 1st, 1872, by C. William Siemens, F.R.S.

may take place when I complete the battery connection. The resistance of both branch circuits being the same, no deflection of the needle is observable on depressing the key,

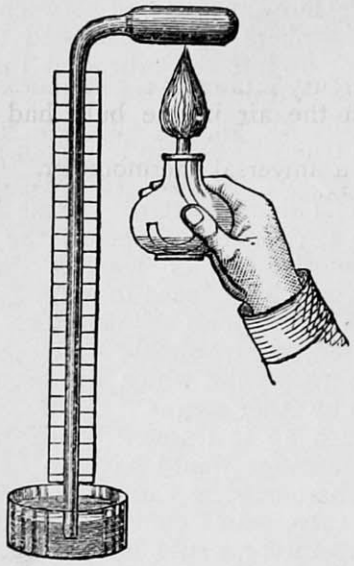

Fig. 1

but when I pass the flame of a spirit-lamp under the one platinum coil, the needle is thrown immediately over to the right, because the electrical resistance of the heated

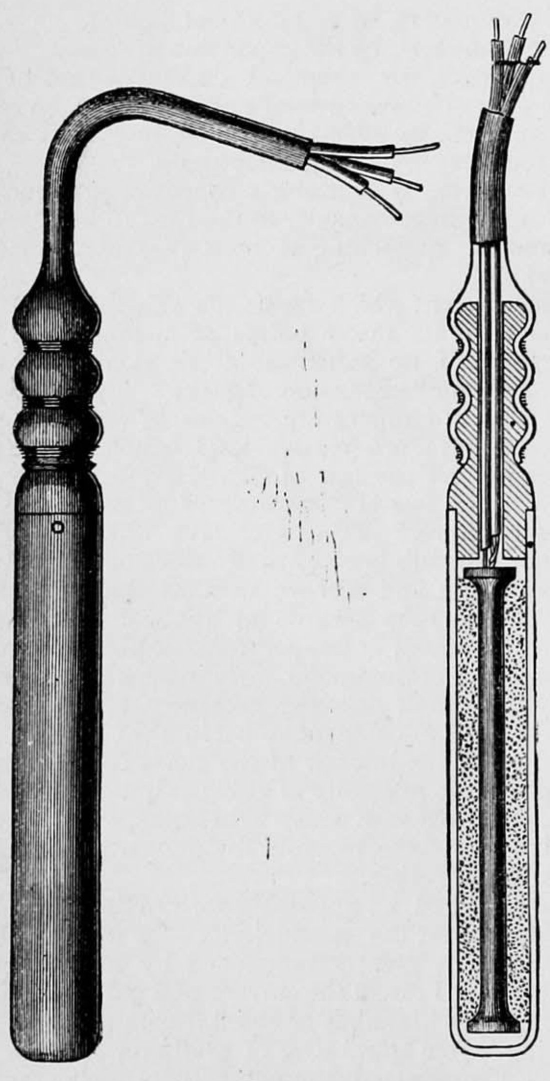

Fig. 2

wire is increased, and consequently a larger proportion o the current is passing through the cooler circuit, exercising a preponderating influence upon the galvani needle. When I withdraw the spirit flame from the wire the needle rapidly returns to its zero position, but in passing it under the other spiral wire the needle immediately deflects in the opposite direction.

If instead of using the open spirals I were to wind thin insulated wire of any pure metal upon two small cylindrical pieces of wood, and were to enclose the tiny spirals in small silver casings, as shown in view and in section by Fig. 2, taking care that the extremities of the spiral wires were soldered to thicker insulated wires leading respectively to the battery and differential galvanometer before mentioned, it follows that no deflection of the needle ensues when both the protected and equal spirals are dropped into a jar containing iced water. But if I take one of the spirals from the water, and place it, for instance, by his kind permission, into the hands of our President, without disconnecting the same from its leading wires, the balance of resistance will no longer take place, and a deflection of the needle to the right actually takes place. I will now endeavour, however, to re-establish the equilibrium by adding warm water to the iced water surrounding the comparison coil near me until no

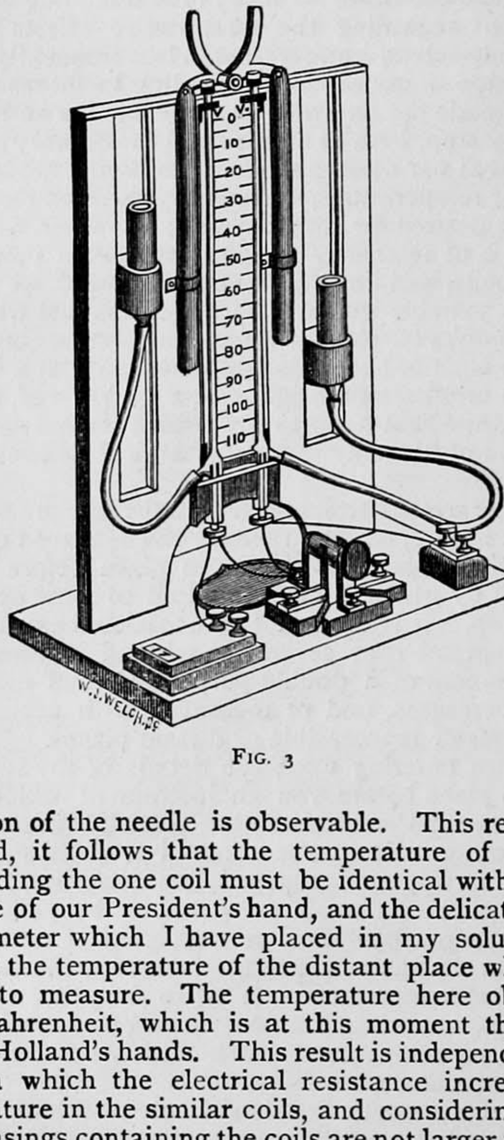

Fig. 3

deflection of the needle is observable. This result being obtained, it follows that the temperature of the water surrounding the one coil must be identical with the temperature of our President's hand, and the delicate mercury thermometer which I have placed in my solution must give me the temperature of the distant place which I intended to measure. The temperature here observed is 89·5° Fahrenheit, which is at this moment that of Sir Henry Holland's hands. This result is independent of the ratio in which the electrical resistance increases with temperature in the similar coils, and considering that the silver casings containing the coils are not larger than small pencil-cases, this method might be advantageously employed in physiological research. The one coil would only have to be placed within the cavity to be measured, to enable the observer to read the temperature from time to time, without disturbing the patient, with the accuracy of which the mercury or spirit of wine thermometer employed is capable. But the same method is applicable for measuring the temperatures of distant or inaccessible places, such as the interior of stores or cargoes of materials liable to spontaneous combustion, of points elevated above the surface of the ground, or of great depths below for meteorological purposes, or for measuring the temperature of the sea continuously in attaching such a coil to the mariner's sounding lead. An error would in such cases arise, however, through the uncertainty of the resistance of long leading wires, if a complete remedy of error from such a source had not suggested itself. This consists in uniting three separate insulated leading wires into a cable by which the distant coil is connected with the measuring instrument. One galvanic circuit passes from the battery through one of the leading wires, through the distant spiral, and back again through the second leading wire to the differential galvanometer and the battery, and the second passes from the same battery through the near coil, and through the third leading wire up to the distant coil without traversing the same, and back again through the second leading wire to the galvanometer and battery. Thus both galvanic circuits comprise the leading wires up to the distant coil, and all variations of resistance by temperature to which the leading wires may be subjected affect both sides of the balance equally. In constructing coils for measuring deep-sea temperatures a large quantity of insulated copper or iron wire is wound upon a metallic tube open at both ends to admit the sea-water freely in order to impart its temperature to the innermost layers of the insulated wire. The coil of wire is protected externally by drawing a tube of

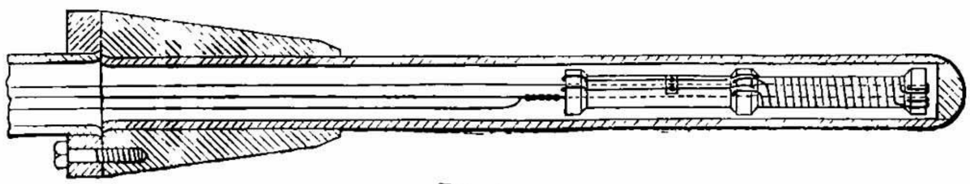

FIG 4

vulcanised india-rubber over it, which in its turn is bound round by a close spiral layer of copper wire, whereby the sea-water is effectually excluded from the sensitive coil. By these arrangements the temperature of distant or otherwise inaccessible places can be accurately ascertained; but the method is limited to the range of temperature which can be obtained and measured in the comparison bath. In order to realise a pyrometer by electrical resistance, it is necessary to rely upon the absolute measurement of the electrical resistance of a coil of wire which must be made to resist intense heats without deteriorating through fusion or oxidation. Platinum is the only suitable metal for such an application, but even platinum wire deteriorates if exposed to the direct action of the flame of a furnace, and requires an external protection. The platinum wire used has, moreover, to be insulated and supported by a material which is not fused or rendered conductive at intense heats, and the disturbing influence of leading wires had in this case also to be neutralised. These various conditions are very fully realised by the arrangement represented on the preceding diagram, Fig. 4.

Thin platinum wire is coiled upon a cylinder of hard-

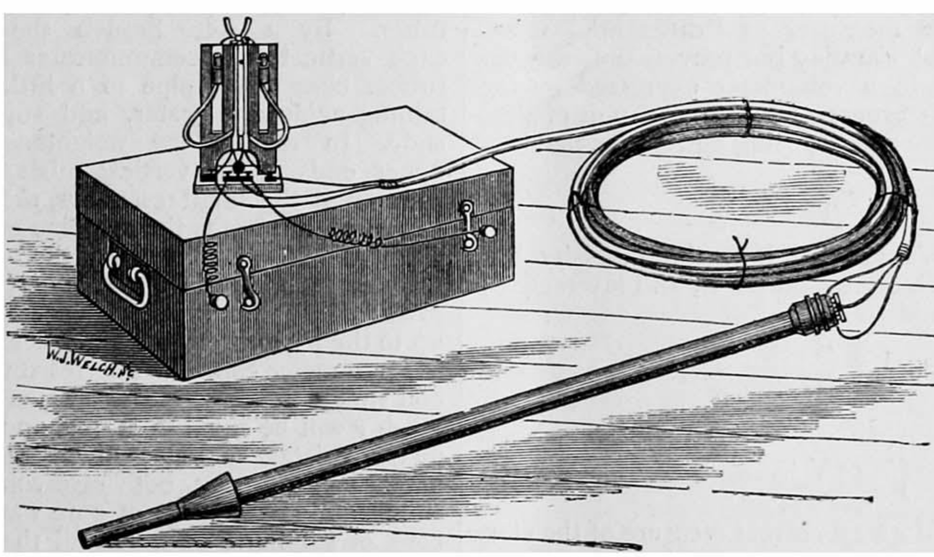

FIG. 5

baked porcelain, upon the surface of which a double-threaded helical groove is formed for its reception, so as to prevent contact between the coils of wire. The porcelain cylinder is pierced twice longitudinally for the passage of two thick platinum leading wires, which are connected to the thin spiral wire at the end. In the upper portion of the porcelain cylinder the two spiral wires are formed into a longitudinal loop, and are connected crossways by means of a platinum binding screw, which admits of being moved up or down for the purpose of adjustment of the electrical resistance at the zero of Centigrade scale. The porcelain cylinder is provided with projecting rims, which separate the spiral wire from the surrounding protecting tube of platinum, which is joined to a longer tube of wrought iron, serving the purpose of a handle for moving the instrument. If the temperatures to be measured do not exceed a moderate white heat, or say 1,300° Centigrade = 2,372° Fah., it suffices to make the lower protecting tube also of wrought iron, to save expense. This lower portion only, up to the conical enlargement or boss of iron, is exposed to the heat to be measured. Three leading wires of insulated copper united into a light cable connect the pyrometer with the measuring instrument, which may be at a distance of some hundred yards from the same. They are connected by means of binding screws at the end of the tube to three thick platinum wires passing down the tube to the spiral of thin platinum wire. Here two of the leading wires are united, whereas the third traverses the spiral, and joins itself likewise to one of the two former, which forms the return wire for two electrical circuits, the one comprising the spiral of thin wire, and the other returning immediately in front of the same, but traversing in its stead a comparison coil of constant resistance. The measuring instrument may consist of a differential galvanometer as before, if to the constant resistance a variable resistance is added. If the pyrometer coil were to be put into a vessel containing snow and water, the balance of resistance between the two battery circuits would be obtained without adding variable resistance to the coil of constant resistance, and the needle of the differential galvanometer would remain at zero when the current is established. But on exposing the pyrometer to an elevated temperature, the resistance of its platinum coil would be increased, and resistance to the same amount would have to be added to the constant resistance of the measuring instrument, in order to re-establish the electrical balance. This additional resistance would be the measure of the increase of temperature, if only the ratio in which platinum wire increases in electrical resistance with temperature is once for all established. This is a question which I shall revert to after having completed the description of the pyrometric instrument.

Although I have explained that by means of a differential galvanometer and a variable resistance (constituting in effect a Wheatstone bridge arrangement) the increasing resistance of the platinum spiral may be measured, it was found that the use of a delicate galvanometer is attended with considerable practical difficulty in iron-works and other rough places where it is important to measure elevated temperatures, or on board ship for measuring deep-sea temperatures. I was therefore induced to seek the same result by the conception of an instrument which is independent in its action from tremulous motion, or from magnetic disturbance caused by moving masses of iron, and which requires no careful adjustment or special skill on the part of the operator. This instrument is represented by Fig. 3 on page 48, and may be termed a chemical resistance measurer or "differential voltameter." The immortal Faraday has proved that the decomposition of water in a voltameter expressed by the volumes of gases V, is proportionate in the unit of time to the intensity I of the decomposing current, or that

$$I = \frac{V}{T}.$$

According to Ohm's general law, the intensity I is governed by the electro-motive force E, and inversely by the resistance R, or it is

$$I = \frac{E}{R}.$$

It is therefore

$$\frac{V}{T} = \frac{E}{R} \quad \text{or } V = \frac{ET}{R};$$

or the volume V would give a correct measure of the electrical resistance R, if only the electro-motive force E and time T were known and constant quantities. But the electromotive force of a battery is very variable; it is influenced by polarisation of the electrodes, by temperature, and by the strength and purity of the acid employed. The volume of gases obtained is influenced, moreover, by the atmospheric pressure, and it is extremely difficult to make time observations correctly. It occurred to me, however, that these uncertain elements might be entirely eliminated in combining two similar voltameters in such a manner that the current of the same battery was divided between the two, the one branch comprising the unknown resistance to be measured, and the other a known and constant resistance. The volume of gas V^1 produced in this second voltameter, having a resistance R^1 in circuit, would be expressed by

$$V^1 = \frac{E\,T}{R^1},$$

and we should have the proportion of

$$V : V^1 = \frac{E\,T}{R} : \frac{E\,T}{R^1};$$

or E and T, being the same in both cases, may be struck out, and the expression will assume the simple form

$$V : V^1 = R^1 : R.$$

The constant resistance R of the one circuit being known, it follows that the unknown resistance R^1 is expressed by $\frac{R^v}{V^1}$; that is to say, by a constant multiplied by the proportion of gas produced in the two voltameters irrespective of time, or strength of battery, or temperature, or the state of the barometer.

The resistance R and R^1 are composed each of two resistances, namely, that of the principal coils, which we may term R or R^1, and of the voltameter and leading wires, which is the same in both cases, and may be expressed by y. The expression should therefore be written as follows:—

$$V : V^1 = R^1 + y^1 : R + y,$$

R^1 being the unknown quantity.

The mechanical arrangement of the instrument will be understood from the diagram, Fig. 3; and the whole arrangement of the pyrometer, with its leading wire and resistance measurer, from the general view given in Fig. 5. The voltametric resistance measurer consists of two calibrated vertical tubes of glass of about 3 millimetres diameter, which are fixed upon a scale showing arbitrary but equal divisions. The upper ends of the tubes are closed by small cushions of india-rubber pressed down upon the openings by means of weighted levers, whereas the lower portions of the tubes are widened out and closed by plugs of wood, through which the electrodes in the form of pointed platinum wires penetrate to the depth of about 25 millimetres into the widened portions of the tubes. By a side branch the widened portion of each vertical tube communicates by means of an india-rubber connecting pipe to a little glass reservoir containing acidulated water, and supported in a vertical slide. In raising the weighted cushions closing the upper ends of the vertical tubes, and in adjusting the position of the small reservoirs, the acidulated water will rise in both tubes to the zero line of the scale. In turning a button in front of the tubes the battery current is passed through both pairs of electrodes, the one circuit comprising the permanent resistance R and the leading wires up to the pyrometer, and the other the leading wires and the pyrometer coil. If the resistance of the pyrometer coil should be equal to the permanent resistance R, then $R^1 + y$ will be equal to $R + y$, and therefore $V = V^1$, but as the resistances differ, so will the volumes. Necessary conditions are, that both reservoirs are filled with the same standard solution of pure water with about 10 per cent. of sulphuric acid, that all the electrodes are of the same form and size, and that their polarity is reversed frequently during the progress of each observation, in order to avoid unequal polarisation. With these precautions, which involve no particular skill or knowledge of electrical observation on the part of the operator, very accurate results are obtained; but in order not to incur considerable error of observation, it is advisable not to continue the current, reversing the same, say twice, until at least forty divisions of gases are produced in the least activated tube, which operation will occupy from two to three minutes, if a battery of from four to six Daniel elements is employed. The volumes V and V^1 being noted, after having allowed half a minute for the gases to collect after the current has ceased, the weighted cushions upon the tubes are raised in order to allow the gases to escape, when the water levels will immediately return to their zero position, to make ready for another observation. By inserting the observed values for V and V^1 into the expression above given, the unknown resistance R^1 can be easily calculated; but in order to facilitate the use of the instrument, I have prepared a table which gives at a glance the resistance due to any two observed volumes, the volumes V governing the vertical, V^1 the horizontal columns, and the resistance being read off at the point of intersection. At each point of intersection the resistance is marked in black, and the corresponding temperature in red ink.

It now remains only to be shown what is the relation between the resistance and temperature in heating a platinum wire. The researches of Dr. Matthiesen, who has made the latest investigations on the effect of temperature upon electrical resistance, are restricted to the narrow range of temperatures between 0° and 100° Centigrade, nor do they comprise platinum. He adopted the following general expression for the pure metals:—

$$R_t = \frac{R_0}{1 + xt + yt^2}$$

which, in determining the specific values of x and y for each metal, gives a close agreement with observation between the narrow limits indicated, but is wholly inapplicable for temperatures exceeding 200° Centigrade, when the value t^2 commences to predominate and to produce absurd values for R_t.

It was necessary for my purpose to undertake a series of elaborate experiments with a view of finding a ratio of general application. Coils of thin wire, of platinum, iron, copper, and some other metals, were gradually heated and cooled in metallic chambers containing the bulbs of mercury thermometers, and for higher temperatures of air thermometers, and the electrical resistances were carefully noted. The progressive increase of electrical resistance was thus compared directly with the increasing volume of a permanent gas (carefully dried) between the limits of zero and 470° Centigrade, and a ratio established which is represented by the formula—

$$R_t = \alpha T^{\frac{1}{2}} + \beta T + \gamma,$$

in which T signifies total temperature counting from the absolute zero, and α, β, and γ specific coefficients for each metal. According to this formula the electrical resistance is a constant at the absolute zero, and progresses in a ratio represented graphically by a tipped-up parabola, approaching more and more toward a uniform ratio at elevated temperatures. Although the comparison with the air thermometer could only be carried up to 470° C., the general correctness of the ratio of increase just stated has been verified by indirect means in measuring progressive heats, and by comparison with the platinum ball pyrometer.

It is important to mention here that great care must be exercised in the selection of the platinum wire for the measuring spiral, platinum wire having been met with conducting only 4·7 times better than mercury at zero C., and others conducting 8·2 times better than mercury, although both samples had been supplied by the same eminent makers, Messrs. Johnson and Mathey. The abnormal electrical resistance of some platinum wire is due chiefly to the admixture of iridium or other metals of the same group, and it appears that the platinum prepared by the old welding process is purer and therefore better suited for electrical purposes than the metal consolidated by fusion in a Deville furnace.

In conclusion, I shall show some working results of the pyrometer in measuring by means of the same protected coil a mixture of ice and water, boiling water, molten lead, and the fire itself by which the lead is melted, the readings produced being 2° C., 98° C., 330° C., and 860° C. respectively. The latter temperature signified a cherry red heat, as may be judged by the appearance of the tube when withdrawn from the fire. The instrument which I have had the honour to bring before you this evening has already received several useful applications. Through its first application an important telegraph cable was saved from destruction through spontaneous generation of heat. Prof. Bolzani, of Kasan, has made some interesting applications of it for recording the temperature at elevated points and at points below the earth's surface. Mr. Lowthian Bell has used it in his well-known researches on blast-furnace economy; and at several iron-works pyrometer tubes are introduced into the heating stoves, and permanently connected with the office, where the heat of each stove can at all times be read off and recorded. These and other applications are sufficiently self-evident, if the soundness of the principles upon which I rely is conceded; but I feel that the shortness of time at my command has hardly enabled me to do more than to pass these in review, while endeavouring to demonstrate the results obtained of recording the temperatures of distant or inaccessible places, including furnace temperatures.

NOTES

THE "Faraday lecture" of the Chemical Society will take place on Thursday, May 30, at 8 o'clock, in the theatre of the Royal Institution, Albemarle Street. This lectureship, founded in honour of the late Prof. Faraday, was inaugurated two years since by a masterly address given by M. Dumas of Paris. Prof. Cannizzaro of Palermo has consented to deliver the lecture this year, which will be anticipated with much interest; he has chosen as his subject "Considérations sur quelques points de l'Enseignement théorique de la chimie."

AT the meeting of the Royal Geographical Society held on Monday evening last, Sir Henry Rawlinson said that the opinion of the Council of the Society was favourable to the authenticity of the intelligence received by telegram respecting Dr. Livingstone. They had every reason to expect that Dr. Livingstone and Mr. Stanley would meet about the beginning of the year. But if there had been any discovery and relief, it was Dr. Livingstone that had discovered and relieved Mr. Stanley, and not Mr. Stanley who had discovered and relieved Dr. Livingstone; because Dr. Livingstone was in clover and Mr. Stanley was absolutely destitute. They knew by the last account that Mr. Stanley was without supplies, and he must have undergone much difficulty in getting to Ujiji; whereas this place was the head-quarters of Dr. Livingstone's supplies. He expected that they would have full letters in the course of a fortnight from Zanzibar, which would inform them on what was known about Dr. Livingstone and Mr. Stanley, and in the meantime he could only say that the telegram was credible.

WE exceedingly regret to have to announce the death, after a short illness (but too probably the effect of overwork), of Mr. George Robert Gray, F.R.S., Senior Assistant Keeper of the Zoological Collections in the British Museum, and an ornithologist of world-wide reputation through his numerous works. Of these we need only particularise two—but two such as have never been executed by any other man—the "Genera of Birds," in three folio volumes (1844-1849), illustrated by the late Mr. Mitchell, some time secretary of the Zoological Society, and by Mr. Wolf, showing an amount of labour at that time unparalleled; and the "Hand-list of Birds," only completed last year, and compiled with a like amount of assiduity. Both these are works found to be indispensable by advanced students of Ornithology in every country; a fact which is alone sufficient proof of their value. The magnificent bird gallery in the British Museum, probably the most popular portion of that building, owes its chief importance to Mr. Gray's labours; and we hope that, in selecting a successor to fill his post, the trustees will not hold themselves bound by any rule of routine, but will take care that the officer in whose charge the splendid collection will be placed is one whose appointment will command the confidence of ornithologists, not in this country only, but throughout the world.

Just before going to press we have received the new scheme for the Natural Sciences, prepared by the Board of Studies at Oxford. We can only at present note the publication of this important document, of which we will give the main features next week.

At the meeting of the French Academy on May 6, MM. Mascart and Janssen were selected to be recommended to the Minister of Public Instruction as candidates for the Chair of General and Experimental Physics at the College of France, vacant by the resignation of M. Regnault.

A meeting of gentlemen who have within the last fifty years attended the Natural Philosophy class in the University of Edinburgh was recently held, to consider the best means of recognising the long services of Mr. James Lindsay, Experimental Assistant to the Professor of Natural Philosophy. Mr. Lindsay has been connected with the University for the last 58 years, and has acted as Experimental Assistant to the Professor of Natural Philosophy for 53 sessions, serving successively Prof. Sir John Leslie, Principal James David Forbes, and Prof. P. G. Tait. Mr. Lindsay has assisted these gentlemen in their original investigations, and has thus been intimately associated with the progress of physical science in Scotland within the last half-century. All have borne unqualified testimony to his accuracy as an experimentalist. Mr. J. C. Young, of 4, Brighton Place, Portobello, and Mr. James Dewar, of 15, Gilmour Place, Edinburgh, are the secretaries to the committee, and will gladly receive subscriptions in aid of the fund, which, we doubt not, will speedily be collected for so worthy an object.

At the meeting of the Zoological Society on June 4, Prof. Owen will read a paper upon a new large wingless bird recently discovered in the post-tertiary deposits of Queensland, Australia. Prof. Owen refers these remains to a new genus of *Struthiones*, allied to the Emeu (*Dromæus*), which he proposes to call *Dromornis*.

The Conversazione of the Society of Arts is fixed to take place at the South Kensington Museum on Wednesday, the 19th of June.

The President of the Institution of Civil Engineers, Mr. Hawksley, has issued cards of invitation for a conversazione on Tuesday, the 28th inst., in the Western Galleries of the International Exhibition Buildings at Kensington.

Dr. Hooker has just issued his Report of the Royal Gardens at Kew for the year 1871. The number of visitors has not been quite equal to either of the two preceding years; but the director attributes this entirely to the diminished number of those classes whose presence is in every way undesirable: the number of visitors who take an intelligent interest in the gardens and their productions being, he believes, steadily on the increase. The number of Sunday visitors is more than two-thirds of the total number on all the other days of the week; Monday, the "artisans' day," showing considerably the largest numbers of any of the week days, and Dr. Hooker speaks of the almost uniformly orderly conduct of the visitors on this day, contrasting in some instances favourably even with that displayed by some of the fashionable Saturday visitors. In the Botanic Gardens no change of importance has been introduced, except the making of a few more shrubberies, and bringing together various scattered young trees by threes or in clumps, so as to give more extent of lawn in certain parts, and broader masses of foliage in others. The works in the Pleasure Grounds and Arboretum have been almost uninterruptedly continued, and a very large space has been planted, partly with young trees brought from the plantations in the Queen's garden, &c., and partly with smaller things to act as a shelter to these. The interchange of living plants and seeds has been continually kept up with similar establishments abroad and in the colonies; and a gardener has been sent out to Jamaica to re-establish the Botanic Garden there, at the request of the Governor, Sir J. P. Grant.

The following works, bearing more or less on Science, are announced as in the press:—By Messrs. Longmans—"An Exposition of Fallacies in the Hypothesis of Mr. Darwin," by Mr. C. R. Bree, M.D., F.Z.S., 8vo, with plates; "As Regards Protoplasm," by Mr. J. H. Stirling. New and improved edition, completed by the addition of Part II. in reference to Mr. Huxley's second issue, and a new preface in reply to Mr. Huxley in "Yeast;" and by Messrs. Strahan—"Town Geology," by the Rev. Charles Kingsley.

The first part has just appeared of the long-expected Flora of British India by Dr. J. D. Hooker, published under the authority of the Secretary of State for India in Council. The territory included in the Flora is that comprised within the British territories in India (including the Malay Peninsula and the Andaman Isles), together with Kashmir and Western Tibet, but excluding Affghanistan and Beluchistan, the plants of which countries are included in Boissier's "Flora Orientalis," and belong to quite another botanical region, that of Western Asia. Of the 12,000 to 14,000 species of flowering plants and ferns belonging to British Indian botany, not a twelfth part has hitherto been brought together in any one general work on Indian plants; the description of the remainder being scattered through innumerable British and foreign journals, or contained in local floras or works on general botany; and a very large number being either very badly described, or not at all. The work is, therefore, one of considerable labour as well as importance, Dr. Hooker being assisted in it by various other botanists. There are a large number of new species described in this part; and the natural orders included in it are Ranunculaceæ, Dilleniaceæ, Magnoliaceæ, Anonaceæ, Menispermaceæ, Berberideæ, Nymphœaceæ, Papaveraceæ, Capparideæ, Resedaceæ, Bixineæ, Violaceæ, and Pittosporeæ, by Dr. Hooker and Dr. Thomson; Cruciferæ by Dr. Hooker and Dr. Anderson; Fumariaceæ by Dr. Hooker; and a part of Polygaleæ by Mr. A. W. Bennett.

The Annual Report of the Maidstone and Mid-Kent Natural History and Philosophical Society for 1871 refers to the successful attempt made during the year to introduce instruction by means of science classes in connection with the society. The senior classes of all the schools in Maidstone have been enrolled in one great class for the study of Physical Geography, and a class of over 300 pupils, constant in their attendance, receives weekly lectures on this subject. The instruction is given gratuitously by members or officers of the Society, and the apparatus has also been provided or constructed by them. A class is also in operation for the study of Inorganic Chemistry. The Society is by this means performing a most useful function in spreading a love of science among our school-boys.

An error has been pointed out to us in the article entitled "English Rainfall in 1871" which appeared in our issue of April 18. One inch of rain is computed at 22,500 gallons per acre, instead of, as it should be, $\frac{6,272,640}{277,274} = 22,623$ gallons, or more exactly 22,622·532, per acre. The error applies to columns γ and δ of the table there given, and to the first half of the second paragraph following, the error being equivalent to 123 in every 22,500 gallons. The correct estimate of the rainfall on a square mile during the year is $22,623 \times 640 \times 22·42 =$ 324,612,902 gallons, or 14,739,053 hectolitres, nearly.

*HISTORY OF THE NAMES CAMBRIAN AND SILURIAN IN GEOLOGY**

(*Concluded from page 37*)

THE Lingula flags and Tremadoc slates have been made the subject of careful stratigraphical and palæontological studies by the Geological Survey, the results of which are set forth by Ramsay and Salter in the third volume of the Memoirs of the Geological Survey, published in 1866, and also, more concisely, in the Anniversary Address by the former to the Geological Society in 1863. (Geol. Jour. XIX. xviii.) The Lingula flags (with the underlying Menevian, which resembles them lithologically) rest in apparent conformity upon the purple Harlech rocks both in Pembrokeshire and in Merionethshire, where the latter appear on the great Merioneth anticlinal, long since pointed out by Sedgwick. The Lingula flags (including the Menevian), have in this region, according to Ramsay, a thickness of about 6,000ft. Above these, near Tremadoc and Festiniog, lie the Tremadoc slates, which are here overlain, in apparent conformity, by the Lower Llandeilo beds. At a distance of eleven miles to the north-west, however, the Tremadoc slates disappear, and the Lingula flags are represented by only 2,000ft. of strata; while in parts of Caernarvonshire and in Anglesea the whole of the Lingula flags and moreover the Lower Cambrian rocks are wanting, and the Llandeilo beds rest directly upon the ancient crystalline schists. In Scotland and in Ireland, moreover, the Lingula flags are wholly absent, and the Llandeilo rocks there repose unconformably upon grits regarded as of Lower Cambrian age. Thus, without counting the Tremadoc slates, which are a local formation unknown out of Merionethshire, we have (including the Bangor group and Lingula flags) beneath the Llandeilo, over 9,000ft. of fossiliferous strata, which disappear entirely in the distance of a few miles. From a careful survey of all the facts, the conclusion of Ramsay is irresistible, that there exist between the Lingula flags and the Llandeilo not merely one, but two great stratigraphical breaks in the succession; the one between the Lingula flags and the Lower Tremadoc slates, and the other between the Upper Tremadoc slates and the Lower Llandeilo.

This conclusion is confirmed by the fact that there exists at each of these horizons a nearly complete palæontological break. The fauna of the Tremadoc slates is, according to Salter, almost entirely distinct from that of the Lingula flags, and not less distinct from that of the so-called Lower Llandeilo or Arenig rocks (the equivalents of the Skiddaw slates of Cumberland). Hence, says Ramsay, it is evident "that in these strata we have three perfectly distinct zones of organic remains, and therefore, in common terms, three distinct formations." The palæontological evidence is thus in complete accordance with that furnished by stratigraphy. We cannot leave this topic without citing the conclusion of Ramsay, that "each of these two breaks necessarily implies a lost epoch, stratigraphically quite unrepresented in our area; the life of which is only feebly represented in some cases by the fossils common to the underlying and overlying formation." In connection with this remark, which we conceive to embody a truth of wide application, it may be said that stratigraphical breaks and discordances in a geological series may, *a priori*, be expected to occur most frequently in regions where this series is represented by a large thickness of strata. The accumulation of such masses implies great movements of subsidence, which, in their nature, are limited, and are accompanied by elevations in adjacent areas, from which may result, over these areas, either interruptions in the process of sedimentation, or the removal, by sub-aerial or sub-marine denudation, of the sediments already formed. The conditions of succession and distribution, it may be conceived, would be very different in a region where the period corresponding to this same geological series was marked by comparatively small accumulations of sediment upon an ocean-floor subjected to no great movements.

This contrast is strikingly seen between the conformable series of less than 2,000 feet of strata which in Scandinavia are characterised by the first three palæozoic faunas (Cambrian and Silurian) and the repeatedly broken and discordant succession of more than 30,000 feet of sediments† which in Wales are their palæontological equivalents. It must, however, be considered that in regions of small accumulation where, as in Scandinavia, the formations are thin, there may be lost or unrepresented zoological epochs whose place in the series is marked by no stratigraphical break. In such comparatively stable regions, movements of the surface sufficient to cause the exclusion, or the disappearance by removal, of the small thickness of strata corresponding to an epoch, may take place without any conspicuous marks of stratigraphical discordance.

The attempt to establish geological divisions or horizons upon stratigraphical or palæontological breaks must always prove fallacious. From the nature of things, these, whether due to non-deposition or to subsequent removal of deposits, must be local; and we can say confidently that there exists no break in life or in sedimentation which is not somewhere filled up and represented by a continuous and conformable succession. While we may define one period as characterised by the presence of a certain fauna, which, in a succeeding epoch, is replaced by a different one, there will always be found, in some parts of their geographical distribution, a region where the two faunas commingle, and where the gradual disappearance of the old before the new may be studied. The division of our stratified rocks into systems is therefore unphilosophical, if we assign any definite or precise boundaries or limitations to these. It was long since said by Sedgwick with regard to the whole succession of life through geologic time—that all belongs to one great *systema naturæ*. (Philos. Mag. IV. viii. 359.)

We have already noticed that Barrande, as early as 1852, gave the name of Primordial Silurian to the rocks which, in Bohemia, were marked by the first fauna; although he, at the same time, recognised this as distinct from and older than the second fauna, discovered in the Llandeilo rocks, which Murchison had declared to represent the dawn of organic life. Into the reasons which led Barrande to include the rocks of the first, second, and third fauna in one Silurian system (a view which was at once adopted by the British Geological Survey and by Murchison himself), it is not our province to inquire; but we desire to call attention to the fact that the latter, by his own principles, was bound to reject such a classification. In his address before the Geological Society in 1842 (already quoted in the first part of this paper) he declared that the discussion as to the value of the term Cambrian involved the question "whether there was any type of fossils in the mass of the Cambrian rocks different from those of the Lower Silurian series. If the appeal to nature should be answered in the negative, then it was clear that the Lower Silurian type must be considered the true base of what I had named the protozoic rocks; but if characteristic new forms were discovered, then would the Cambrian rocks, whose place was so well established in the descending series, have also their own fauna, and the palæozoic base would necessarily be removed to a lower horizon."

In the event of no distinct fauna being found in the Cambrian series, it was declared that "the term Cambrian must cease to be used in zoological classification, it being in that sense synonymous with Lower Silurian." (Proc. Geol. Soc. iii. 641 *et seq.*) That such had been the result of palæontological inquiry Murchison then proceeded to show. Inasmuch as the only portion of Sedgwick's Cambrian which was then known to be fossiliferous, was really above and not below the Llandeilo rocks, which Murchison had taken for the base of his Lower Silurian, his reasoning with regard to the Cambrian nomenclature, based on a false datum, was itself fallacious; and it might have been expected that when the Government surveyors had shown his stratigraphical error, Murchison would have rendered justice to the nomenclature of Sedgwick. But when, still later, a farther "appeal to nature" led to the discovery of "characteristic new forms," and established the existence of a "type of fossils in the mass of the Cambrian rocks different from those of the Lower Silurian series," Murchison was bound by his own principles to recognise the name of Cambrian for the great Festiniog group, with its primordial fauna, even though Barrande and the Government surveyors should unite in calling it Primordial Silurian.

He however chose the opposite course, and now attempted to claim for the Silurian system the whole of the Middle Cambrian or Festiniog group of Sedgwick, including the Tremadoc slates

* Reprinted from advance sheets of the *Canadian Naturalist*.

† The Longmynd rocks in Shropshire are alone estimated at 20 000 feet; but their supposed equivalents, the Harlech rocks of Pembrokeshire, have a measured thickness of 3,300, while the Llanberis and Harlech rocks together, in North Wales, equal from 4,000 to 7,000 feet, and the Lingula flags and Tremadoc slates, united, about 7,000 feet. The Bala group in the Berwyns exceeds 12,000 feet, and the proper Silurian, from the base of the Upper Llandovery or May Hill sandstone, attains from 5,000 to 6,000 feet; so that the aggregate of 30,000 feet may be considered below the truth. (Mem. Geol. Survey, iii. part 2, pages 72, 222, and Siluria, 4th ed. 185.)

and the Lingula flags. The grounds of this assumption, as set forth in the successive editions of "Siluria" from 1854 to 1867, and in various memoirs, may be included under three heads: first, that the Lingula flags have been found to exist in some parts of his original Silurian region; second, that no clearly-defined base had been assigned by him to his so-called system; and third, that there are no means of drawing a line of demarcation between these Middle Cambrian formations and the overlying Llandeilo.

With regard to the first of these reasons, it is to be said that the only known representatives of the Lingula flags in the region described by Murchison in his "Silurian System" are the black slates of Malvern, and some scanty outliers which, in Shropshire, lie between the old Longmynd rocks and the base of the Stiper-stones. The former were then (as has already been shown) supposed by him to belong to the Llandeilo, or rather to the passage-beds between the Llandeilo and Cambrian (Bala); while with regard to the latter, Ramsay expressly tell us that they were not originally classed with the Silurian, but have since been included in it. (Mem. Geol. Sur. iii. part 2, page 9; and 242, foot-note.)

The Llandeilo beds were by Murchison distinctly stated to be the base of the Silurian system (Sil. Sys. 222); and it was further declared by him that in Shropshire (unlike Caermarthenshire) "there is no passage from the Cambrian to the Silurian strata," but a hiatus, marked by disturbances which excluded the passage-beds, and caused the Lower Silurian to rest unconformably upon the Longmynd rocks. (Ibid, 256; and plates 31, sections 3 and 6; 32, section 4.) But in "Siluria" (1st ed. 47) the two are stated to be conformable; and in the subsequent sections of this region, made by Aveline, and published by the Geological Survey, the evidences of this want of conformity do not appear. Murchison at that time confounded the rocks of the Longmynd with the Cambrian (Bala) beds of Caermarthenshire and Brecon. (Sil. Sys. 416). Hence it was that he gave the name of Cambrian to the former; and this mistake, moreover, led him to place the Cambrian of Caermarthenshire beneath the Landeilo. It is clear that if he claimed no well-defined base to the Llandeilo rocks in this latter (their typical region), it was because he saw them passing into the overlying Bala beds. There was, in the error by which he placed *below* the Llandeilo, strata which were really *above* them, no ground whatever for afterwards including in his Silurian system, as a downward continuation of the Llandeilo rocks (which are the basal portion of the Bala group), the whole Festiniog group of Sedgwick; whose infra-position to the Bala had been shown by the latter long before it was known to be fossiliferous.

It was, however, claimed by Murchison that no line of separation can be drawn between these two groups. The results of Ramsay and of Salter, as set forth in the address of the former before the Geological Society in 1863, and more fully in the Memoirs of the Geological Survey (vol. iii. part 2) published in 1866, with a preface by himself, as the director of the Survey, are completely ignored by Murchison. The reader familiar with these results, of which we have given a summary, finds with surprise that in the last edition of "Siluria," that of 1867, they are noticed in part, but only to be repudiated. In the five pages of text which are there given to this great Middle Cambrian division, we are told that the distinction between the Lower Tremadoc and the Lingula flags "is difficult to be drawn," and that the Upper Tremadoc slate passes into and forms the lower part of the Llandeilo, "into which it graduates conformably" ("Siluria," 4th ed. p. 46). In each of these cases, on the contrary, according to Ramsay, there is observed "a break very nearly complete both in genera and species, and probable unconformity;" the evidence of the palæontological break being furnished by the careful studies of Salter; while that of the stratigraphical break, as we have seen, leaves no reason for doubt. (Mem. Geol. Sur. iii. part 2, pp. 2, 161, 234). The student of "Siluria" soon learns that in all cases where Murchison's pretensions were concerned, the book is only calculated to mislead.

The reader of this history will now be able to understand why, notwithstanding the support given by Barrande, by the Geological Survey of Great Britain, and by most American geologists, to the Silurian nomenclature of Murchison, it is rejected, so far as the Lingula-flags and the Tremadoc slates are concerned, by Lyell, Phillips, Davidson, Harkness, and Hicks in England, and by Linnarsson in Sweden. These authorities have, however, admitted the name of Lower Silurian for the Bala group or Upper Cambrian of Sedgwick; a concession which can hardly be defended, but which apparently found its way into use at a time when the yet unravelled perplexities of the Welsh rocks led Sedgwick himself to propose, for a time, the name of Cambro-Silurian for the Bala group. This want of agreement among geologists as to the nomenclature of the lower palæozoic rocks, causes no little confusion to the learner. We have seen that Henry Darwin Rogers followed Sedgwick in giving the name of Cambrian to the whole palæozoic series up to the base of the May Hill sandstone; and the same view is adopted by Woodward in his Manual of the Mollusca. The student of this excellent book will find that in the tables giving the geological range of the Mollusca, on pages 124, 125, and 127, the name of Cambrian is used in Sedgwick's sense, as including all the fossiliferous strata beneath the May Hill sandstone. On page 123 it is however explained that Lower Silurian is a synonym for Cambrian, and it is so used in the body of the work.

The distribution of the Lower and Middle Cambrian rocks in Great Britain may now be noticed. The former, or Bangor group, to which Murchison and the Geological Survey restrict the name of Cambrian, and which they sometimes call the Longmynd, bottom or basement rocks, occupy two adjacent areas in Caernarvon and Merionethshire; the one near Bangor, including Llanberis, to the north-east, and the other, including Harlech and Barmouth, to the south-east of Snowdon; this mountain lying in a synclinal between them, and rising 3,571 feet above the sea. The great mass of grits or sandstones appears to be at the summit of the group, but in the lower part the blue roofing slates of Llanberis are interstratified in a series of green and purple slates, grits, and conglomerates (some of the Welsh roofing-slates are, however, supposed to belong to the Llandeilo). (Mem. Geol. Survey iii. part 2, pages 54, 258). The Harlech rocks in this north-western region are conformably overlaid by the Menevian, followed by the true Lingula-flags, or Olenus beds, of the Middle Cambrian. Upon these repose the Tremadoc slates, which are not known in the other parts of Wales. The third area of Lower Cambrian rocks is that already described at St. David's in Pembrokeshire, about 100 miles to the south-west; and the fourth, that of the Longmynd hills, about sixty miles to the south-east of Snowdon. The rocks of the Longmynd, like those of the other Lower Cambrian areas mentioned, consist principally of green and purple sandstones with conglomerates, shales, and some clay-slates. They occasionally hold flakes of anthracite, and small portions of mineral pitch exude from them in some localities. The only evidence of animal life yet found in the rocks of the Longmynd is furnished by worm-burrows, the obscure remains of a crustacean (the *Palæopyge Ramsayi*) and a form like *Histioderma*. This latter organic relic, with worm-burrows, and the fossils named *Oldhamia*, is found on the coast of Ireland opposite Caernarvonshire, in the rocks of Bray Head; which resemble lithologically the Harlech beds, and are regarded as their equivalents.

Still another area of the older rocks is that of the Malvern hills, on the western flanks of which, as already mentioned, the Lingula flags are represented by about 500 feet of black shales with *Olenus*, underlain by 600 feet of greenish sandstones containing traces of fucoids, with Serpulites and an *Obolella*. It is not improbable, as suggested by Barrande and by Murchison, that these 1,100 feet of strata represent, in this region, the great mass of the Lingula flags, and, we may add, perhaps the whole series of Lower Cambrian strata, which in Caernarvonshire and Pembrokeshire underlie them; since these sandstones of Malvern, like those of St. David's, rest upon crystalline schists, and are in part made up of their ruins.

These crystalline schists of Malvern, which are described by Phillips as the oldest rocks in England, and by Mr. Hull are conjectured to be Laurentian, seem, from the descriptions of their lithological characters, to resemble those of Caernarvon and Anglesea, with which they are, by Murchison, regarded as identical. The crystalline schists of these latter localities are by Sedgwick described as hypozoic strata, below the base of the Cambrian. Murchison, however, in the first edition of his "Siluria," adopted the suggestion of De la Beche that they themselves were altered Cambrian strata. In fact, they directly underlie the Llandeilo rocks, and were apparently conceived by Murchison to represent the downward continuation of these, upon which he had insisted. This opinion is supported by ingenious arguments on the part of Ramsay (Mem. Geol. Survey, iii. part 2, *passim*). I am however disposed to regard them, with Sedgwick and Phillips, as of pre-Cambrian age, and to compare them with the Huronian series of North America, which occupies a similar geological

horizon, and with which, as seen in northern Michigan, and in the Green Mountains, I have found the rocks of Anglesea to offer remarkable lithological resemblances.

It may here **be noticed** that the gold-bearing quartz veins in North Wales are **found** in the Menevian beds, and also, according to Selwyn, throughout the Lingula flags. These fossiliferous strata at the gold mine near Dolgelly appear in direct contact with diorites and chloritic and talcose schists, which are more or less **cupriferous**, and themselves also contain gold-bearing quartz veins (Mem. Geol. Survey, part 2, pp. 42, 45, and Siluria, 4th ed., 450, 547).

The following table gives a view of the lower palæozoic rocks of Great Britain and North America, together with the various nomenclatures and classifications referred to in the preceding pages. In the second column, the horizonal black lines indicate the positions of the three important palæontological and stratigraphical breaks signalised by Ramsay in the British succession (Mem. Geol. Survey, iii. part 2, page 2). In a table by Davidson in the *Geological Magazine* for 1868 (v. 305) showing the distribution of organic remains in these lower rocks, he gives, as the Festiniog group of Sedgwick, only the Dolgelly and Maentwrog beds of Belt (the Upper and Middle Lingula flags), and makes of the two divisions of the Tremadoc rocks a separate group; the whole being described as the Upper Cambrian of Sedgwick. This, however, is not the present grouping and nomenclature of Sedgwick, nor was it his earlier one. So far as

LOWER PALÆOZOIC ROCKS OF EUROPE AND NORTH AMERICA

	BRITISH SUB DIVISIONS.	NORTH AMERICAN SUB-DIVISIONS.	NOMENCLATURES OF SEDGWICK AND MURCHISON.	BARRANDE'S CLASSIFICATION.	ANGELIN'S DIVISIONS.
14	Ludlow.	Lower Helderberg.	Silurian, *Sedgwick.* Upper Silurian, *Murchison.*	Third fauna, including Etages H, G, F, E.	VIII. VII., or Regiones E, and **DE.**
13	Wenlock.	Niagara, Clinton,			
12	Upper Llandovery.	Medina, Oneida.			
11	Lower Llandovery.	Hudson-River, Utica,	Upper Cambrian or Bala group, *Sedgwick.* Lower Silurian, *Murchison.*	Second fauna, including Etage D.	VI. V. IV., or Regiones D, C, and BC.
10	Caradoc.	Trenton, Birdseye,			
9	Upper Llandeilo.	Black-River.			
8	Lower Llandeilo.	Chazy.			
7	Upper Tremadoc.	Levis.	Middle Cambrian or Festiniog group, *Sedgwick.* Primordial Silurian, *Murchison.*	First fauna, or Primordial fauna, including Etage C, and probably also Etage B.	III. II. I., or Regiones B, and A, and Regio Fucoidarum.
6	Lower Tremadoc.	Calciferous.			
5	Dolgelly.	Potsdan..			
4	Maentwrog.				
3	Menevian.	Braintree and St. John.	Lower Cambrian or Bangor group, *Sedgwick.* Cambrian, *Murchison.*		
2	Harlech.	——— ?			
1	Llanberis.	——— ?			

regards Middle and Upper Cambrian, this discrepancy is explained by the fact already stated, that in 1843 Sedgwick proposed as a compromise the name of Cambro-Silurian for his Bala group, previously called Upper Cambrian; by which change the Festiniog or Middle Cambrian became Upper Cambrian. When the true relation between the Lower Silurian of Murchison and the Bala group was made known, Sedgwick, as we have seen, re-claimed for the latter his former name of Upper Cambrian; but this had meanwhile been adopted for the Festiniog group, in which sense it is still used by Lyell, Phillips, Davidson, Harkness, and Hicks. The Festiniog group, or Middle Cambrian, as defined by Sedgwick, however, included not only the whole of the Lingula flags, but the Upper and Lower Tremadoc rocks (Philos. Mag. IV. viii, 362).

The only change which I have made in the groupings of the British rocks adopted by Sedgwick and by Murchison, is in separating the Menevian or Lower Lingula flags from the Festiniog, and uniting it with the Bangor group or Lower Cambrian. In this I follow, with Lyell and Davidson, the suggestion of Salter and Hicks.

In the third column, the sub-divisions are those of the New York and Canada Geological Surveys; in connection with which the reader is referred to a table published in 1863, in the "Geology of Canada," p. 932. Opposite the Menevian I have placed the names of its principal American localities, which are Braintree, Mass., St. John, New Brunswick, and St. John's, Newfoundland. With regard to the classification of Angelin, it is to be remarked that, although he designates II. as *Regio Olenorum*, and III. as *Regio Conocoryphorum*, the position of these, according to Linnarsson, is to be reversed; the Conocoryphe beds with *Paradoxides* being below, and not above, those holding *Olenus*. The *Regio Fucoidarum* in Sweden has lately furnished a brachiopodous shell, *Lingula monilifera*, besides the curious plant-like fossil, *Eophyton Linnæanum*. (Linnarsson, Geol. Mag., 1869, vi. 393.)

T. STERRY HUNT

SOCIETIES AND ACADEMIES

LONDON

Zoological Society, May 7.—Prof. Newton, V.P., F.R.S., in the chair. The secretary read a report on the additions that had been made to the society's collection during the month of March, 1872, amongst which were two red-necked bustards (*Eupodotis denhami*), presented by Mr. C. D. O'Connor and Governor Ussher, and a Beatrix antelope (*Oryx ebatrix*) from the Persian Gulf, received on deposit. —Mr. P. L. Sclater exhibited and made remarks on a skull of the Hairy Tapir of the Andes (*Tapirus roulini*) obtained by Mr. Buckley during his recent expedition to Ecuador.—Prof. Owen read the eighteenth of his series of memoirs on the extinct birds of the genus Dinornis and its allies, in which was contained the description of the pelvis and bones of the leg of *Dinornis gravis*, a supposed new species allied to *D. crassus*, and a general *résumé* of the described species of the genus *Dinornis.*—The Viscount Walden, F.R.S., communicated an appendix to his paper on the birds of Celebes, read at a former meeting of the society, and containing an account of twelve species to be added to the Celebean Avifauna. This raised the total number of known species of Celebean birds to 205.—Mr. Henry Buckley exhibited the eggs of three species of North American birds, which he believed had never previously been obtained. The eggs were those of *Falco polyagrus*, *Elanoides furcatus*, and *Ictinia Mississippiensis.*—Mr. H. E. Dresser exhibited the egg of *Querquedula marmorata*, collected in Spain by Major Irby, this being probably the first authenticated instance of the breeding of this bird in Spain.—A communication was read from Mr. W. H. Hudson, containing field notes on the habits of the swallows, of the genus *Progne*, met with in the Argentine Republic. To this was added some notes on the species by Mr. P. L. Sclater.—A communication was read from Mr. G. French Angus, containing descriptions of ten new species of land and marine shells, mostly from Australia.—A second communication from Mr. Angus contained the description of a new species of *Voluta*, proposed to be called *Voluta hargravesi.*—A paper by Mr. H. Adams was read, in which he described a new species of *Geotrochus* from the Island of New Britain, proposed to be called *G. fergusoni.*—A communication was read from Dr. J. E. Gray, F.R.S., containing a description of *Peltastes forsteni*, a species of land tortoise from Celebes.—Two communications were read from Mr. J. M. Brazier, giving descriptions of land and marine shells collected in Australia and Lord Howe's Island.—A communication was read from Mr. A. Anderson, containing some additional notes on the Raptorial birds of North Western India.—A paper by Dr. J. E. Gray, F.R.S., was read, describing a young Tapir from the Peruvian Amazons, which he proposed to call *Tapirus terrestris peruvianus.*—A communication was read from Dr. J. E. Bowerbank, F.R.S., containing the third part of his contributions to a general history of the *Spongiadæ*.

Entomological Society, May 6.—Mr. H. T. Stainton, F.R.S., vice-president, in the chair.—Mr. E. Saunders exhibited a series of species of Australian *Buprestidæ*, illustrating the great sexual differences existing in these insects.—Mr. F. Smith exhibited a large collection of *Hymenoptera*, chiefly *Aculeata*, sent by Mr. G. Lewis from Hiogo in Japan. The whole collection was strikingly European in its aspect, though the species were in most cases different; the genera were all represented in Europe save one genus of ants.—Mr. Verrall exhibited an example of *Syrphus lasiophthalmus* with a peculiar malformation of two tibiæ, which appeared as though they had been broken, probably when the insect had just emerged from the puparium, and badly united afterwards. — Mr. Stainton exhibited an aspen leaf, sent by Lord Walsingham from Oregon, pierced by a multitude of small oval holes, caused by small mining micro-lepidopterous larvæ, which each detached an oval case formed of the cuticles of the leaf. These cases had produced a minute moth of the genus *Aspidisca*, which he also exhibited.—Mr. E. Saunders read "Descriptions of twenty new species of *Buprestidæ*."—Mr. H. W. Bates read a memoir on the Longicorn *Coleoptera* of Chontales, Nicaragua; enumerating 242 species sent home by Mr. Belt, and describing the new forms. This collection elicited two general facts—firstly, the homogeneity of the insect fauna of the forest region of tropical America, over, probably, 45 degrees of latitude, and, secondly, the existence of a distinct northern element, whose metropolis is Central America.

Chemical Society, May 2.—Dr. Frankland, F.R.S., president, in the chair. Mr. E. Riley delivered his lecture on the Manufacture of Iron and Steel. The lecturer in his discourse treated of the influence of the elements associated with iron in the pig, and the part they play in the subsequent conversion of pig into wrought-iron and steel. Although in certain districts there is not much variation in the pig made, the same ore and fuel being constantly used, yet in others, as South Wales and Staffordshire, so many varieties of ore are employed that pig of all descriptions is produced. From the results of the analysis of samples of Yorkshire hot-blast pig (No. 1 to 6 iron) from the same works, it would appear that whilst the phosphorus is almost constant in all the kinds, namely, about 0·9 per cent, the quantity of sulphur decreases and that of silicon increases with the number. It is possible that the differences in the amount of sulphur present would explain the differences in the quality of the pig, for it is certain that sulphur makes grey iron white; but, at the same time, the different numbers of grey iron may be produced by differences in the rate of cooling. On examining the pigs from which the best wrought-iron is made, they will be found to contain silicon and phosphorus. Swedish iron, which contains no phosphorus and but little silicon, when used by itself, gives red short iron. It will be seen from this that silicon and phosphorus play an important part in the manufacture of iron. Hæmatite pig frequently contains as much as 4 or 5 per cent. of silicon. The chief constituents of pig-iron are, besides iron, carbon, silicon, sulphur, phosphorus, and manganese, traces of copper and titanium (the latter only in grey iron), frequently nickel and cobalt, and occasionally vanadium and arsenic. The per-centage of carbon in pig iron varies from 3 to 4 per cent., but the question as to whether it forms any definite compound with iron is open to great doubt. Mr. Snelus has shown that by sifting out the finer portions from the borings of Middlesboro' pig a material could be obtained containing 7 per cent. of carbon, and by elutriation one containing more than 41 per cent. The sulphur seems always to be derived from the sulphide of iron present in the fuel or ore, but from some experiments it would seem that an excess of lime may act on the sulphide in the coke and convert it into sulphide of calcium and metallic iron. Silicon is always present to a greater or less extent in iron. With respect to phosphorus, practically speaking, all that is present both in the ore and in the fuel passes into the iron. After some remarks on the comparatively small value of titanium as an ingredient of iron, the speaker discussed the quality and composition of the fuel employed in smelting, and then passed on to the process of refining. The time required for this seems to depend on the quantity of silicon present in the pig, much of it being separated during the operation, along with some sulphur and phosphorus, and a little carbon. The process of puddling was then described, and the merits of the various machines for superseding manual labour discussed, with especial reference to the results obtained with that of Mr. Danks; the great advantage of machine puddling being the uniform quality of the wrought-iron made. In conclusion the author made some remarks especially with reference to the occurrence of silicon in steel. This elaborate and exhaustive memoir was copiously illustrated by analyses.

BOOKS RECEIVED

ENGLISH.—The Earth's Crust: D. Page (Blackwoods).—The Flora of British India, Part 1.: Dr. J. D. Hooker (L. Reeve and Co.).—Air and Rain; the beginning of a Chemical Climatology: R. Angus Smith (Longmans).—Man in the Past, Present, and Future: D. L. Büchner, translated by W. S. Dallas (Assher and Co.).—Naval Science, No. 1: Edited by E. J. Reed (Lockwood).

AMERICAN.—The Geological Survey of Ohio; Report of Progress, 1870: J. S. Newberry.

DIARY

THURSDAY, MAY 16.

ROYAL SOCIETY, at 8.30.—On the Specific Heat and other Physical Characters of Mixtures in Methylic Alcohol and Water: Dr. Dupré.—On Supersaturated Saline Solutions, Part III.: C. Tomlinson, F.R.S., and G. Van der Mensbrugghe.—Remarks on the Sense of Sight in Birds: Dr. R. J. Lee.

SOCIETY OF ANTIQUARIES, at 8.30.—Prehistoric Implements in Eden ide, near St. Bees, Cumberland: R. D. Darbishire, F.G.S.

CHEMICAL SOCIETY, at 8.

FRIDAY, MAY 17.

ROYAL INSTITUTION, at 9.—On the more important Substitutes for Gunpowder: Prof. Abel, F.R.S.

SATURDAY, MAY 18.

ROYAL INSTITUTION, at 3.—On the Chemical Action of Light: Prof. Roscoe, F.R.S.

GOVERNMENT SCHOOL OF MINES, at 8.—On Geology: Dr. Cobbold, F.R.S.

MONDAY, MAY 20.

ANTHROPOLOGICAL INSTITUTE, at 8.—On a New Instrument for Measuring the Proportions of the Human Body: Joseph Bonomi.—On Moral Irresponsibility resulting from Insanity: George Harris.

TUESDAY, MAY 21.

ZOOLOGICAL SOCIETY, at 9.—On the Royal Antelope and allied species of *Nanotragus*: Sir Victor Brooke, Bart.—Notes on the Anatomy of the Huia Bird: A. H. Garrod.

ROYAL INSTITUTION, at 3.—On Development of Belief and Custom: E. B. Tylor.

WEDNESDAY, MAY 22.

GEOLOGICAL SOCIETY, at 8.—On the Phosphatic Nodules of the Cretaceous Rock of Cambridgeshire: Rev. O. Fisher, F.G.S.—Some Observations on the Upper Greensand Formation of Cambridge: W. Johnson Sollas. Notes on Sand-pits, Mud Volcanoes, and Brine-pits, met with during the Yarkand Expedition of 1870: Dr. G. Henderson.

SOCIETY OF ARTS, at 8.—On Painted Metallic Hangings for Mural Decorations: G. Clark.

THURSDAY, MAY 23.

ROYAL INSTITUTION, at 3.—On Heat and Light: Prof. Tyndall, F.R.S.

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