THURSDAY, SEPTEMBER 20, 1888.

A TEXT-BOOK OF PHYSIOLOGY.

A Text-book of Physiology. By J. G. McKendrick, M.D. LL.D., F.R.S. Including "Histology," by Philipp Stöhr, M.D. In Two Volumes. Vol. I. General Physiology. (Glasgow: MacLehose and Sons. London: Macmillan and Co. 1888.)

THE present volume deals with the general principles of biology, the chemistry of the body, the early stages of development, the microscope, and the methods of microscopical research, the histology of the tissues and the physiology of muscle. It is no doubt very difficult to say what should and what should not be included in a text-book of physiology. The primary object is to explain as much as we can of the phenomena of the animal organism by physical and chemical laws. To understand such an explanation, a knowledge of chemistry, physics, and of the structure of the organism is essential. These subjects are treated of in special text-books which do not contain any physiology, and their introduction into a work devoted to this subject cannot fail to exert an injurious influence on the full exposition of the actual state of the science.

The present work is noticeable for the large amount of subsidiary matter which has been introduced, rather than as being a very complete account of modern physiology. The book is, however, intended by its author to aid the student to an intelligent knowledge of physiology, or rather, of all the subjects which are commonly dealt with by lecturers on physiology. It supplies the physical and chemical information more immediately required in physiological problems; it explains the methods by which the more important results have been obtained; and it gives a general insight into important biological facts.

Considering the very wide range of subjects, the choice of matter has been very well adapted to the object in view, and the book will doubtless find a larger circle of readers than the Professor's own class, for which it is especially intended. However, the degree to which the various sections have been brought up to date is very unequal. Some of the subjects have evidently been thoroughly worked up, whilst others appear to have been chiefly compiled from existing and not wholly modern text-books. In a work of this character, unless the author be endowed with almost superhuman industry, such a result is inevitable, and is fully foreseen by the author himself.

The section devoted to the general structure and physiology of the cell, the phenomena of fertilization, and the modern views on heredity, will certainly be much appreciated. General biological knowledge of this kind is often eagerly sought for by the student, and not always readily obtainable.

The microscope and the methods of microscopical research are very good and modern, but this is a subject which is hardly expected in a text-book of physiology. The histology of the tissues calls for no special comment.

In connection with the physiology of muscle, the object and use of the graphic method is explained with great care, very clear and good illustrations being given of the apparatus used. Muscle physiology itself is treated in considerable detail, to which is added the physiology of the electrical organ in fishes, containing the recent researches of Prof. Sanderson and Mr. Gotch. The physiology of smooth muscle is very scantily touched on, and the figures in connection with the heat produced by muscle are not correct; nor is any reference made to the observations of Ludwig and Meade Smith, on the heat produced in the mammalian muscle when tetanized under different conditions of blood-supply. Surely they are much more to the point than the observations of Billroth and Fick, which are only applicable to the organism as a whole.

The best feature in the chemical part of the work is the introduction of sections on the general chemical processes of the organism and on fermentation. With regard to the former, the paragraph devoted to reduction—as an important chemical process of the organism—is too short: the interesting observations of Ehrlich on the reducing powers of the tissues (as shown by the injection of alizarin-blue, endophenol-white) are surely worthy of mention. The undoubted fact that the blood of asphyxiated animals contains reducing substances is not alluded to, nor is the *rôle* which modern physiological chemists ascribe to these reducing substances in producing nascent oxygen, and so bringing about the oxidations of the tissues, pointed out with sufficient clearness. Fermentation is considered in its historic aspect, and from its chemical and biological sides. The history of organized ferments is adequately treated, as are also the early and important observations of Pasteur. What we actually know about the relationship of enzymes and organized ferments is not clearly expressed, no account being given of the researches of Musculus, Lea, and others, which have shown that enzymes can be obtained from organized ferments. Nor is the question of the chemical nature of enzymes sufficiently discussed.

The remainder of the section of chemistry contains numerous defects. Thus a long chapter is devoted to the signification of chemical formulæ, but we are later told of the albumins that their "chemical constitution oscillates round the following: $C_{54}H_7N_{16}O_{22}S$." No mention is made of the observations of Schmiedeberg, Drechsel, or Grubler, on artificial albumin crystals—observations of the highest importance for all future work on proteids. The accounts given of casein, mucin, and nuclein are not in accordance with our present knowledge. The chemical relations of indigo are given in detail, but the indican of the urine is said to have the formula $C_{26}H_{31}NO_{17}$, and no mention is made of indoxyl potassium sulphate. So with uric acid, nothing is said about the most important facts of Horbaczewski and E. Ludwig on the formation of uric acid from glycocoll and urea, which correspond so well with Strecker's view of uric acid as a body analogous with hippuric acid (the benzoic acid being replaced by cyanic), and with the remarkable physiological fact observed by Wöhler, that calves, as long as they feed on milk, excrete only uric acid, and no hippuric, whilst the reverse is the case when they take to a vegetable diet. Again, in regard to the formation of uric acid, two extremely important researches have been made—that of Schroeder on the influence of ammonia salts in producing uric acid in birds, and the remarkable confirmation of this by Minkowski, who found, after extirpation of the liver, the uric acid of the bird's urine replaced by ammonia.

The subject most fully treated is that of the pigments, but here again the important works of Nencki and Sieber on hæmoglobin and its derivatives, find no mention. A work like the present is necessarily a compromise. It does not give so equable and well-judged an account of what it is important to know in physiology as might be expected from the reputation of the author and the size of the book; but it shows the judgment of an experienced teacher in endeavouring to make every subject perfectly intelligible and in leaving no branch of physiological science untouched. L. C. WOOLDRIDGE.

OUR BOOK SHELF.

The Mind of the Child. Part I. The Senses and the Will; Observations concerning the Mental Development of the Human Being in the First Year of Life. By W. Preyer, Professor of Physiology in Jena. Translated from the original German by H. W. Brown. "International Education Series." (New York: Appleton and Co. London: Whittaker and Co. 1888).

IT is with no small satisfaction that we notice the issue of this work in the English language. It has already remained much too long in the German and French tongues only; and it speaks ill for the enterprise of British publishers that now the name of Appleton appears upon the cover. For, although comparisons as a rule are invidious, in the present instance there can be no doubt that the work in question holds the first place in the literature of the subject with which it deals. And since the study of infant psychology was inaugurated by M. Taine and Mr. Darwin, it has become so popular a branch of scientific literature that an English translation of "Die Seele des Kindes" must be an assured success, even from a commercial point of view.

In the case of a book already so well known, it is needless to say much by way of analysis. We must remark, however, that the present volume comprises only Parts I. and II. of the original—the remainder being reserved for publication as a second volume. Hence the instalment of the translation now before us deals only with the senses and the will; the next instalment having to treat of the intellect, and all supplementary matter. As everyone who has read the original is aware, Prof. Preyer has devoted himself to his subject with an assiduity and a thoroughness which only an assured conviction of its importance could inspire. And, in the result, his patiently continuous observation, his skilled intelligence as a well-read psychologist, together with his high attainments as a professed physiologist, combine to render his work, not only as before remarked the most important, but also in many respects the most interesting, that has hitherto appeared upon the subject of psychogenesis. Therefore we recommend this work to all our English readers as the best that they can procure on "the mind of the child"—and this whether their interest in such a mind be scientific only or likewise parental.

G. J. R.

Arithmetical Exercises. By H. S. Hall, M.A., and S. R. Knight, B.A. (London: Macmillan and Co., 1888.)

IN this book we have a collection of examples comprising about eighty progressive miscellaneous exercises and a set of fifty papers taken from such examinations as the London University, Oxford and Cambridge Local, Previous Cambridge, Army Preliminary, &c. The examp'es are judiciously chosen, and great care seems to have been taken to make the work as progressive as possible. An appendix is added, consisting of two hundred graduated questions in logarithms and mensuration, preceded by a list of the numerical constants and formulæ used in the latter. The answers to the examples are all collected together at the end.

An Elementary Treatise on Mensuration. By E. T. Henchie. (London: School Books Publishing Company, 1888.)

IN this work we have an excellent treatise for those who are about to begin the study of this subject. All reference to trigonometry has purposely been avoided, and the author has in the second chapter added the enunciations of Euclid's propositions which bear on the work, together with an explanation of each.

Plain rectilinear figures, curvilinear areas, the circle, surfaces and volumes of solids, are dealt with in turn, and each chapter is accompanied by a set of illustrative examples thoroughly worked out and explained, followed by a separate set to be worked out by the student. Land surveying forms the subject of the eighth chapter, in which are described the various instruments with the methods of using them. The figures throughout are very clear, and the shading used in those of the chapter on solids is excellent. The book concludes with a set of miscellaneous examples, making in all about 1260, together with the answers to the above.

LETTERS TO THE EDITOR.

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Lamarckism *versus* Darwinism.

I HAD hoped that my previous letter might have closed this correspondence, but Mr. Poulton's reply suggests to me the propriety of making one additional remark. This is, that while writing the sentence in the *Contemporary Review* to which he has taken exception, it never occurred to me that anyone would gather from it that I intended to disparage the work of an eminent man, who happens to be also a personal friend. But, as this appears to be the impression conveyed to Mr. Poulton, I should not like to allow his statement of it to pass unnoticed. As a matter of fact, no one can appreciate more thoroughly than I do the extensive knowledge, the clearness of thought, and the great powers of original research which are now being so conspicuously displayed by Prof. Weismann.

From the first it has been sufficiently obvious to me how the present misunderstanding arose; and if, instead of affirming that I was ignorant of Prof. Weismann's writings, Mr. Poulton had begun as he has ended, by asking me to "explain" my remark with reference to them, of course I should at once have done so. However, as stated in my last letter, it is my intention at no very distant date to deal with the whole question of so-called "Lamarckism *versus* Darwinism"; and, therefore, my only object in this communication is to stop from going further the impression that I hold in light esteem the highly important achievements of Prof. Weismann.

GEORGE J. ROMANES.

Geanies, Ross-shire, September 8.

Mr. Gulick on Divergent Evolution.

MR. GULICK'S paper on this subject appears in the last number of the Journal of the Linnean Society as having been "communicated by Alfred Russel Wallace, F.L.S." It may therefore be supposed that I recommended its publication, or that I agree with its main argument; and as this is not the case, I ask permission to say a few words on the subject in the columns of NATURE.

In 1872, Mr. Gulick sent me his paper on "Diversity of Evolution under One Set of External Conditions," requesting me, if I thought fit, to communicate it to the Linnean Society. As the paper contained a body of very interesting facts observed by the author, I had no hesitation in recommending its acceptance by the Society, although I did not agree with the conclusions Mr. Gulick drew from his facts.

Last year Mr. Gulick sent me the manuscript of his present paper, informing me that it was the result of long-continued study of the subject, and asking me to forward it to the Linnean Society. I did so, writing to the Secretary that I had not read the paper through, and did not undertake the responsibility of recommending it for acceptance.

Having now read the paper in print, I find very little in it that I can agree with. I can discover in it no additional facts beyond those which were set before us in the former paper sixeen years ago, while there is an enormous body of theoretical statements, many of which seem to me erroneous, and a highly complex classification of the conditions under which the separation or isolation of individuals of a species takes place, with a new and cumbrous terminology, neither of which, in my opinion, adds to our knowledge or comprehension of the matter at issue.

As in almost every page of this long paper I find statements which seem to me to be either disputable or positively erroneous, any extended criticism of it is out of the question; but I wish to call attention to one or two points of vital importance. Mr. Gulick's alleged discovery is, "the law of cumulative divergence through cumulative segregation" (p. 212). He maintains that any initial variation, if isolated by any of the causes he has enumerated, but remaining under identically the same environment, will increase till it becomes in time a specific or even a generic divergence, and this without any action whatever of natural selection. Now if this is *a fact* it is a most important and fundamental fact, equal in its far-reaching significance to natural selection itself. I accordingly read the paper with continual expectation of finding some evidence of this momentous principle, but in vain. There is a most elaborate discussion and endless refined subdivisions of the varied modes in which the individuals constituting a species may be kept apart and prevented from intercrossing, but no attempt whatever to prove that the result of such complete or partial isolation is "cumulative divergence." The only passage which may perhaps be considered such an attempt at proof is that on p. 219, where he supposes an experiment to be made, and then gives us what he thinks "experienced breeders" will assure us would be the result. In this experiment, however, there is to be constant selection and reassortment of each brood, yet he asserts that "there is no selection in the sense in which natural selection is selection"; by which he appears to mean that the selection is by "separation" not by "extermination." This, however, seems to me to be a distinction without a difference.

Again, in the various illustrations of how "cumulative segregation" is brought about, natural selection must always come into play—as in the case of a change in digestive powers, and consequent adoption of a different food (p. 223), leading to partial isolation; and such cases are exactly what is contemplated by Darwin in his brief statement of the effects of "divergence of character" ("Origin," pp. 86–90), while the concurrence of "isolation" as a factor is fully recognized at pp. 81–83 of the same work (6th edition).

It appears to me that throughout his paper Mr. Gulick omits the consideration of the inevitable agency of natural selection, arising from the fact of only a very small proportion of the offspring produced each year possibly surviving. Thus when, at p. 214, he states that "the fact of divergence in any case is not a sufficient ground for assuming that the diverging form has an advantage over the type from which it diverges," he omits from all consideration the fact that at each step of the divergence there was necessarily selection of the fit and the less fit to survive; and that if, as a fact, the two extremes have survived, and not the intermediate steps which led to one or both of them, it is a proof that *both* had an advantage over the original less specialized form. Darwin explains this in his section on "Extinction caused by Natural Selection" (p. 85). On the whole, I fail to see that Mr. Gulick has established any new principle, either as a substitute for, or in addition to, natural selection as set forth by Darwin. Others, however, may think differently; and I shall be glad if any naturalists who have studied Darwin's works will point out, definitely, in what way this paper extends our knowledge of the mode in which species have originated.

ALFRED R. WALLACE.

The Death of Clausius.

I do not know by what unfortunate accident it happened that I did not hear of the death of the great Clausius until after the meeting of the British Association. I write this in order to explain how I neglected to express the sorrow of the scientific world in Britain in the loss, and our sympathy with the scientific world in Germany. It is not the part of a young disciple like me to eulogize the giants of the passing generation, but I regret greatly that any appearance of want of appreciation of the labours of one of the most brilliant lights of the nineteenth century should attach to British science owing to my silence.

GEO. FRAS. FITZGERALD.

Trinity College, Dublin, September 15.

The March Storms.

The accounts of March storms in England which reach us lead me to think that it would be interesting to note the following. On March 13, barometers in Western Australia had fallen suddenly 0·20 inch; the cyclone passed rapidly eastward along the south coast of Australia. On the 15th we had a heavy gale of wind at Sydney; the anemometer showed 55 miles an hour. Lake George was so disturbed that the observer was wind-bound in the small house which holds the recording machine for several days, and the tidal register at Sydney shows considerable disturbance like earthquake-waves during the 15th, 16th, and 17th. On the 15th the level of the Sydney transit instrument was found to have changed suddenly since the 14th, 0''·7, the western pier having fallen. A tidal wave reached New Guinea and New Britain on the 13th; at the latter place it is supposed to have risen 40 feet.

H. C. RUSSELL.

Sydney Observatory, July 26.

INTERNATIONAL METEOROLOGY.

The International Meteorological Committee held a meeting at Zürich, in the Polytechnikum, from the 3rd to the 5th of this month. All the members were present. The most important point on which action was taken was the subject of future meetings to be held instead of Meteorological Congresses organized by diplomatic means. The following was the resolution adopted:—

"The Committee, in view of the circumstance that the assembling of an international meeting, of the same character as the Congresses of Vienna and Rome, presents great difficulties, considers that the commission it received at Rome is exhausted, and that it ought to dissolve itself.

"At the same time, in order to continue the relations between the different meteorological organizations, which have been productive of such good results during a series of years, the Committee appoints a small bureau with the duty of using its best endeavours to bring about, at some convenient time, an international meeting of representatives of the different Meteorological Services."

By a subsequent resolution the bureau was made to consist of the President and Secretary of the Committee (Prof. Wild and Mr. Scott).

Among other matters on which action was taken may be mentioned:—

Cloud Classification.—It was decided that the proposals of Messrs. Hildebrandsson and Abercromby were not ripe enough to be recommended for general adoption.

Meteorological Information from Travellers.—On the motion of Dr. Hann certain rules were laid down, to be recommended to all Geographical Societies, &c., as to the conditions which must be observed in order to render published records of meteorological observations of any real service to meteorology. These relate to instruments and their corrections, exposure, methods of calculation, &c., &c.

The Committee finally dissolved itself.

ROBT. H. SCOTT.

Meteorological Office, September 19.

THE NORWEGIAN GREENLAND EXPEDITION.

INFORMATION having been received by the sealer *Jason* of the Norwegian Expedition under Dr. Fridtjof Nansen, which is to attempt traversing Greenland from the east coast to the west coast, having left that vessel on July 17 in lat. 65° 2′ N., and by this time is no doubt fairly on its way across the inland ice, some particulars of the plan and aim of this expedition, furnished by the leader himself, will doubtless prove of interest, and tend to correct various erroneous statements which have appeared.

When leaving the *Jason*, an ice-belt about ten miles in width separated the vessel from the mouth of the Sermilik Fjord, and the Expedition was seen to make good progress, either walking over the ice or rowing through it, and at 6 a.m. it was out of sight. It was Dr. Nansen's intention to land in this fjord, which is inhabited, and proceed to the bottom, where he would attempt to ascend to the inland ice plateau. The mountains around the fjord are very steep, and upwards of 6000 feet in height, but still this spot was recommended by the Danish explorer, Captain Holm, as the most suitable. It is agreed by all competent authorities that once on the inland ice plateau the rest of the journey will be comparatively easy, Dr. Nansen and his followers purposing to journey on the so-called Norwegian *Ski* across the smooth snowy surface of the inland ice. These adjuncts of locomotion are highly recommended by Baron Nordenskiöld in land journeys in the Arctic regions; and as a proof of their utility it may be mentioned that when on the inland ice in 1883, the two Lapps in his train were sent forward, and covered in fifty-seven hours twice as much ground as the rest of the expedition in twenty-seven days. Before, however, describing these means of locomotion on snow, a brief reference to the members of the Expedition should be made.

The Expedition, for which there were thirty-five volunteers, including one Englishman, consists of Dr. Fridtjof Nansen, of the Bergen Museum, leader; Lieutenant in the Norwegian army, Herr O. C. Dietrichson; Herr Otto Sverdrup, an officer in the Norwegian mercantile marine; and Herr Kristian Kristiansen, a land-owner; with two Lapps, Samuel Bulto and Ole Ravna, the latter of whom was "on view" at the Exhibition in London in 1883. All the members are men in their best years, powerful, and accustomed to hardships of all kinds, and last, not least, experts in the craft of *Skilöbning*, or Norwegian mode of journeying on snow. This mode is entirely different from that practised in Canada under the name of "snow-shoeing," and therefore deserves special mention. The *Ski*, or snow "runners," as they might more justly be called, are long strips of carefully selected pine-wood without a flaw, those used by Dr. Nansen being about 8 feet in length, 1 inch in thickness, and 4 inches in width. In the middle is a leather strap covered with sheep's wool for the foot, and a slight catch for the heel, whilst the edges are (in this particular case) protected by means of a steel band. The wood has been carefully seasoned and soaked in tar to prevent the penetration of moisture, whilst underneath the *Ski* are lined with reindeer skin, the hair of which gives the runner a better "grip" on the snow when going up hill. In front they are pointed and bent slightly upwards, so as to pass more easily over obstacles. A good pair of *Ski* will, when carefully prepared, have the elasticity almost of a Toledo blade, and jumps of 25 or 30 feet, when such may be necessary in the mountains, are frequently performed by good *Ski* men, without breaking their *Ski*. The most remarkable feats of agility are performed by experts on these means of locomotion; in fact, many a Norwegian is as much at home on his *Ski* as a Red Indian on his horse. As to the progress made on *Ski*, it is simply astounding, a good runner on dry snow, and across a fair country, being capable of covering a hundred miles a day, and down hill the speed rivals that of the fastest express. Dr. Nansen and his party, who are all celebrated for their achievements in the *Ski* sport, carry with them nine pairs of these. For the conveyance of provisions he has with him five hand sledges of novel construction, being only half the weight of those generally carried in Arctic journeys. They are 9 feet long, and 2 feet wide, greatly curved at both ends, and shod with steel bands, whilst at the back is a steering-pole. The weight is 25 pounds. Dr. Nansen had occasion to test the quality of one of these sledges when travelling last winter alone across Norway on *Ski*, from Eidsfjord to Nummedal, a distance of about fifty miles. The adoption of this kind of sledge has been made at the instance of Baron Nordenskiöld, who, during his journey across the inland ice, found those then used too heavy. The Expedition is also provided with a tent, brown in colour, in order to afford a rest to the eye on the vast dazzling snow-fields, and it may be separated into five pieces, each forming a sail for the boats. Naturally it was absolutely necessary that the baggage of the Expedition should be as small as possible, consequently only what is absolutely required has been included, such as the usual scientific apparatus, a camera, cooking utensils, and provisions, the latter consisting chiefly of pemmican, meat cakes and biscuits, preserves, tea, chocolate, &c. Every article carried has been specially prepared, some in Christiania, and others in Copenhagen, London, and Paris. One article which previous Greenland Expeditions have been much in want of are Alpine ropes for use in climbing, and these have been specially made for Dr. Nansen in London.

Having reached the inland ice plateau, Dr. Nansen purposes travelling in a north-westerly direction, with Disco Bay on the west coast for his goal, as further south the land is intersected by deep fjords and mountains, which may cause difficulties in crossing. The distance from coast to coast is estimated at 425 miles, and allowing for a rate of progress of only fifteen miles a day, the whole journey should be accomplished in about thirty days. The leader considers it a great advantage to cross from east to west, and not *vice versâ* as previously attempted, as in the former case provisions need only be carried for *one* journey, the west coast being well provided in this respect. The most serious obstacles expected by Dr. Nansen on the inland ice are crevices in the ice, which are formed by the water from the melting snow, and wet snow. The former he intends to attempt evading by sending the Lapps forward as scouts, and on the latter Canadian snow-shoes will be used, as in wet snow the *Ski* are of little use, the snow clogging to them and retarding progress. It is, however, expected that at this season the snow will be crisp and dry. It should also be mentioned that by crossing from east to west the Expedition will have the advantage of travelling continually down an incline, as the country slopes gradually down from a height of 6000 feet on the east coast to only a few hundred on the west coast, whilst the wind also nearly always blows from that quarter.

Dr. Nansen further anticipates that the curious lofty basalt rocks of Disco Island will be seen a good way inland, and serve as a landmark.

As regards the scientific aspects of the expedition, not too great results may be expected, although Dr. Nansen has especially qualified for his task, and visited Greenland some years ago; as with the means at his disposal, and in view of the mode of travelling, the number of members and the weight of the baggage had to be scrictly limited. However, the leader feels confident that it will contribute in some degree to solve the scientific problems facing us in that continent, which has always had such fascination to the geographer, geologist, and botanist in particular, and may lead to the despatch of an Expedition on a larger scale and with a wider scientific scope.

It may be of interest here briefly to recall the attempts which have been made from time to time to cross the Greenland continent.

As is well known, Greenland has never been crossed by human being, although there is a tradition, confirmed by Holm and Garde, that a young girl from Pikiudelek, on the east coast, driven from home by cruelty, wandered on foot across the ice to the west coast. However, in modern times many attempts have been made, as, for instance, by Dalager (a Dane), Dr. John Rae, Messrs. Whymper and Brown, Messrs. Jensen, Kornerup, and Groth, and Nordenskiöld in 1870 and 1883. All of these attempts were failures, with the exception of that of Nordenskiöld in 1883 referred to, when he succeeded, in lat. 68½° N., in reaching 75 miles inland, and his two Lapps 140 miles further, or 215 miles, *i.e.* a little more than half the width of the country. Finally, we have the scantily-known wandering, in June of last year, of Mr. Peary, an Amerian engineer, and Herr Maigaard, a Dane, who claim to have reached about 100 miles inland on the ice from Jakobshavn, and reached an elevation of about 7000 feet above the sea; but the weather was unfavourable. It is worthy of note that this elevation is far higher than that recorded by Nordenskiöld a little further south, viz. about 6000 feet.

It is impossible to close this *résumé* of Dr. Nansen's plans without referring to the much-disputed theory of there being, if not a fertile interior somewhere in Greenland, at all events land free from ice and snow, as advocated by Nordenskiöld, but which he failed to find. We have it however now, on the authority of Dr. Nansen, that in spite of this failure the famous Swedish explorer is still of opinion that such conditions may exist somewhere to the north or south of the track followed by himself. Dr. Nansen also supports this theory, which is, leaving the "Föhn" wind theory out of the question, based, firstly, on the circumstance that the reindeer herds on the west coast disappear from the coast in the summer, when it is surmised that they proceed to this interior "oasis," as it has been termed; and, secondly, on the discovery by Nordenskiöld of reindeer horn far in on the ice; thirdly, the theory is claimed to be supported by the fact of Nordenskiöld's two Lapps having in the middle of Greenland seen two ravens coming from the north to "have a look at them," and return in the same direction. Hence, it is maintained, some ice-free land must exist further north. But as to the wanderings of the reindeer, such take place every summer in Norway, when the animals repair to the glaciers in order to escape from their dread tormentors the gadfly and the heat. It is, however, curious that the Greenlanders themselves, as well as the Eskimo, according to Captain Holm, firmly believe in an ice-free and populated interior, the inhabitants of which are of enormous stature, fierce, and dangerous magicians, and it is this latter belief which is the cause of the natives refusing to act as guides or participate in explorations of the interior. The east coast natives by the way maintain, too, that Scoresby Sound in the extreme north (Holm, "East Coast Expedition, 1883-85") is a fjord separating Greenland from the rest of the Arctic regions; that once a Greenlander sailed through it from west to east, and that near its southern shores resides a warlike tribe of Greenlanders.

It was Dr. Nansen's intention to have attempted to land in the neighbourhood of Scoresby Sound, where no European has ever set foot, but it was impossible to get further north than Cape Dan on account of ice. It should be mentioned that the present expedition is in a great degree due to the munificence of Herr Augustus Gamél, of Copenhagen, who despatched Lieutenant Hovgaard's Arctic Expedition of 1880, and has received valuable assistance from such Greenland explorers as Nordenskiöld, Rink, Holm, Ryder, and Marigaard, as well as the Royal Geographical Society.

If all goes well, it may return to Europe before the last vessel leaves Greenland at the end of September.

If successful, it cannot fail to throw some further light upon the interesting scientific problems of that mystic northern continent, and incite other explorers to follow in Dr. Nansen and his colleagues' footsteps.

THE CENTENARY OF THE CALCUTTA BOTANIC GARDEN.

THE Report of Dr. George King, the Superintendent of the Botanic Garden of Calcutta, for the past year gives a brief history of the work of that institution during the century of its existence, which has just been completed. The suggestion for its foundation was made to the Government in Calcutta in 1786 by Colonel Robert Kyd, then Superintendent of the East India Company's dockyard at Kidderpore. The adoption of the proposal was urged upon the Board in London by the Governor-General, and upon their sanctioning it a large piece of land at Shalimar was chosen as the site, and Colonel Kyd was elected the first Superintendent. He held the post till his death in 1793. At the outset it was understood that the Garden was to be made a source of information for the Company's servants, and a place in which experiments could be made on those exotics which were of economic value. It was also intended to be a horticultural and agricultural garden, which would assist in introducing indigenous Indian products to new markets. The earliest efforts of Colonel Kyd were directed to the introduction of trees yielding nutmeg, cloves, and cinnamon, and to attempt to cultivate them. This, however, was a failure, the climate being shown to be quite unsuitable to them. The equatorial fruits, such as mangosteen and bread-fruit were tried with a similar result, and also the temperate fruits of Europe, and thus at an early stage it was demonstrated that any such effort was quite useless. Colonel Kyd introduced tea cultivation, and in this he was highly successful, and it was owing to his efforts that the tea-industry has become one of the most important in India. On the death of Colonel Kyd, Dr. William Roxburgh, the Company's Botanist in Madras, was appointed to the post, and continued in it till 1814. He was an ardent botanist, and was the first who attempted to draw up a systematic account of the plants of India. His *Flora Indica* contained descriptions of all the indigenous plants he had met, and also of the exotics in cultivation at Calcutta. This book was not published till 1832, and it was, till Sir Joseph Hooker commenced his work on the "Flora of British India" in 1872, the only book from which a good knowledge of Indian plants could be acquired. Besides his "Flora Indica," Roxburgh published "Plantæ Coromandalianæ," descriptions of three hundred of the most representative plants on the Coromandel Coast. Dr. Roxburgh, who left India on account of failing health, was succeeded by Dr. Buchanan-Hamilton, who collected a mass of information about the fauna and flora of India, a portion of which he published in his own name, but the greater part was issued in Montgomery Martin's "History, Topography, and Statistics of Eastern India." In 1817, Dr. Wallich became Superintendent. Wallich was a most energetic man, and during his term of office he made collections in Kumaon, Nepal, Tenasserim, Singapore, Penang, and other places. His collections of dried plants were taken by him to London, and after their classification they were distributed to the chief botanical institutions in Europe. Dr. Wallich published three fine volumes, "Plantæ Asiaticæ Rariores," illustrated with excellent figures. On Dr. Wallich's retirement in 1846, Dr. Hugh Falconer, who is well known on account of his researches on the Sivalik fossil Mammalia, succeeded to the post. Dr. Thomas Thomson, the co-worker of Sir Joseph Hooker in the collection and distribution of an extensive East Indian Herbarium, was the next Superintendent. His successor, Dr. Thomas Anderson, died in 1870 from disease contracted when labouring to introduce the quinine-yielding Cinchonas into the Himalayas. This latter work—that is, the cultivation of the Cinchonas of the Andes—has been a great success. The Garden authorities, in connection with the Agri-Horticultural Society of India, made great and successful efforts to improve the quality of Indian cotton, and to push its sale and that of jute in the European markets. The united bodies also imported better kinds of sugar-cane from the West Indies, and thus improved the quality and the amount of the sugar-crop in India. The various Superintendents made from time to time experiments in the cultivation of plants and products of economic value, as, for instance, tapioca, india-rubber, sarsaparilla, aloes, cocoa, and many others. Many of the various kinds of exotics now grown in India have been introduced through the instrumentality of the Garden, and the authorities have shown to the inhabitants of India the advantages of better systems of cultivation than they previously pursued.

In the year 1864 the Garden was devastated by a terrible cyclone, and the few plants that escaped the general ruin were very much thinned by another cyclone which a few years after burst over Calcutta. In fact, at the present moment there are in the Garden only a few trees, including the great banyan, which were there in 1867. When the shade of the trees was thus removed, the weed *Imperata cylindrica* spread rapidly over the whole Garden, and when Dr. King was appointed to be Superintendent of the Garden, in 1871, he found it in rather a sorry plight. By the assistance that the local authorities gave him he was enabled to plant it afresh, to lay it out for landscape effect, to form ornamental ponds, and to build the Herbarium and conservatories. The most noticeable feature from a botanical stand-point is, of course, the Herbarium. On Dr. Wallich dispersing in 1828 the splendid collection of dried plants, the foundations of another were laid. Almost every botanical student in India has contributed to the present collection, and also many specimens have been sent from Europe. Of course it is above all an Indian Herbarium, but there are also good collections of plants from Asia Minor, Persia, Japan, and South-Eastern Asia. In fact, in all but African and American plants it is a very representative collection. For the last fifty years there has been a constant exchange of specimens with Kew Gardens, and to Sir William Hooker, and Sir Joseph Hooker, and Mr. Thiselton Dyer, the Herbarium owes some of its choicest specimens. Exchanges have also been systematically made with the British Museum Herbarium, the Jardin des Plantes, Paris, the Imperial Gardens at Berlin and St. Petersburg, and with the institutions at Ceylon, Java, and Saharanpore, and many of the best-known botanists have been among the most active contributors.

During the past year the collection of dried plants has been largely increased, the most noteworthy additions being those collected by Dr. Aitchison with the Afghan Boundary Commission, and those by Dr. Giles during the Gilgit expedition, the latter having been sent from Kew. From Kew were also received many specimens of Singapore and Penang plants. Many plants from Central Asia were sent by the Director of the Imperial Garden at St. Petersburg, and a Natal collection was sent from Durban. Four hundred named species from Mexico, a large box of dried plants from New Guinea, a quantity of plants from Sikkim, trees from the Khasia Hills, specimens from the North-Western Himalayas, and from Southern India, were among the many collections presented to the Garden in the past year. The Government Botanist of Perak, Father Scortechini, who had been sent by Sir H. Low, came to the Garden in November to study, so that he might arrange his collections, but he died shortly after his arrival. During the year 8064 plants were received and 46,109 given out; 903 packets of seeds were received, and 2534 distributed. Dr. King concludes his Report by saying that the acclimatized English potatoes have everywhere turned out badly the past season.

THE BRITISH ASSOCIATION.

SECTION G.

MECHANICAL SCIENCE.

OPENING ADDRESS BY WILLIAM HENRY PREECE, F.R.S., M.INST.C.E., &c., PRESIDENT OF THE SECTION.

"CANST thou send lightnings, that they may go, and say unto thee, Here we are?" were pregnant words addressed to Job unknown centuries ago. They express the first recorded idea in history of the potentiality of electricity to minister to the wants of mankind. From Job to Franklin is a long swing in the pendulum of time. It was not until that American philosopher brought down atmospheric electricity by his kite-string in 1747, and showed that we could lead it where we willed, that we were able to answer the question addressed to the ancient patriarch. Nearly another century elapsed before this mysterious power of Nature was fairly conquered. It has been during this generation, and during the life of the British Association, that electricity has been usefully employed; and it is because I have taken a subordinate position in inaugurating nearly all of its practical applications, that I venture to make the developments of them the text of my address to this Section.

People are singularly callous in matters affecting their own personal safety: they will not believe in mysteries, and they ridicule or condemn that which they do not understand. The Church itself set its face against Franklin's "impious" theories, and he was laughed to scorn by Europe's scientific sons; and even now, though Commissions composed of the ablest men of the land have sat and reported on Franklin's work in England, France, and nearly every civilized nation, the public generally remains not only ignorant of the use of lightning-conductors, but absolutely indifferent to their erection, and, if erected, certainly careless of their proper maintenance. I found in a church not very far from here the conducter leaded into a tombstone, and in a neighbouring cathedral the conductor only a few inches in the ground, so that I could draw it out with my hand. Although I called the attention of the proper authorities to the absolute danger of the state of affairs, they remained in the same condition for years.

Wren's beautiful steeple in Fleet Street, St. Bride's, was well-nigh destroyed by lightning in 1764. A lightning-rod was fixed, but so imperfectly that it was again struck. In July last (1887) it was damaged because the conductor had been neglected, and had lost its efficiency.

As long as points remain points, as long as conductors remain conductors, as long as the rods make proper connection with the earth, lightning protectors will protect: but if points are allowed to be fused, or to corrode away; as long as bad joints or faulty connections are allowed to remain; as long as bad earths, or no earths exist, so long will protectors cease to protect, and they will become absolute sources of danger. Lightning-conductors, if properly erected, duly maintained, and periodically inspected, are an absolute source of safety; but if erected by the village blacksmith, maintained by the economical churchwarden, and never insp cted at all, a loud report will some day be heard, and the beautiful steeple will convert the churchyard into a new geological formation.

We have not yet acquired that mental confidence in the accuracy of the laws that guide our procedure in protecting buildings from the effects of atmospheric electrical discharges which characterizes most of the practical applications of electricity. Some of our cherished principles have only very recently received a rough shaking from the lips of Prof. Oliver Lodge, F.R.S., who, however, has supported his brilliant experiments by rather fanciful speculation, and whose revolutionary conclusions are scarcely the logical deduction from his novel premises. The whole subject is going to be thoroughly discussed at this meeting.

We are now obtaining much valuable information about the nature of lightning from photography. We learn that it does not, as a rule, take that zigzag course conventionally used to represent a flash on canvas. Its course is much more erratic and sinuous, its construction more complicated, and pictures have been obtained of *dark* flashes whose *raison d'être* has not yet been satisfactorily accounted for. The network of telegraph wires all over the country is peculiarly subject to the effects of atmospheric electricity, but we have completely mastered the vagaries of lightning discharges in our apparatus and cables. Accidents are now very few and far between.

The art of transmitting intelligence to a distance beyond the reach of the ear and the eye, by the instantaneous effects of electricity, had been the dream of the philosopher for nearly a century, when in 1837 it was rendered a practical success by the commercial and far-sighted energy of Cooke, and the scientific knowledge and inventive genius of Wheatstone. The metallic arc of Galvani (1790) and the developments of Volta (1796) had been so far improved that currents could be generated of any strength; the law of Ohm (1828) had shown how they could be transmitted to any distances; the deflection of the magnetic needle by Oersted in 1819, and the formation of an electro-magnet by Ampère and Sturgeon, and the attraction of its armature, had indicated how those currents could be rendered visible as well as audible.

Cooke and Wheatstone in 1837 utilized the deflection of the needle to the right and the left to form an alphabet. Morse used the attraction of the armature of an electro-magnet to raise a metal style to impress or emboss moving paper with visible dots and dashes. Steinheil imprinted dots in ink on the different sides of a line on paper, and also struck two bells of different sound to affect the ear. Bréguet reproduced in miniature the actual movements of the semaphore, then so much in use in France; while others rendered practical the favourite idea of moving an indicator around a dial, on which the alphabet and the numerals were printed, and causing it to dwell against the symbol to be read—the A, B, C instrument of Wheatstone in England, and of Siemens in Germany. Wheatstone conceived the notion of printing the actual letters of the alphabet in bold Roman type on paper—a plan which was made a perfect success by Hughes in 1854.

At the present moment the needle system of Cooke and Wheatstone, as well as the A, B, C dial telegraph, are very largely used in England on our railways and in our smaller post-offices. The Morse recorder and the Hughes type-printer are universally used on the Continent; while in America the dot-and-dash alphabet of Morse is impressed on the consciousness through the ear by the sound of the moving armature striking against the stops that limit its motion. In our larger and busier offices the Morse sounder and the bell system, as perfected by Bright, are very largely used, while the Press of this country is supplied with news which is recorded on paper by ink dots and dashes at a speed that is almost fabulous.

Sir William Thomson's mirror—the most delicate form of the needle system—where the vibratory motions of an imponderable ray of light convey words to the reader; and his recorder, where the wavy motion of a line of ink spirted on paper by the frictionless repulsion of electricity perform, the same function, are exclusively employed on our long submarine cables.

Bakewell, in 1848, showed how it was possible to reproduce facsimiles of handwriting and of drawing at a distance; and, in 1879, E. A. Cowper reproduced one's own handwriting, the moving pen at one station so controlling the currents flowing on the line wire that they caused a similar pen to make similar motions at the other distant station. Neither of these plans, the former beautifully developed by Caselli and D'Arlincourt, and the latter improved by Robertson and Elisha Gray, have yet reached the practical stage.

The perfection of telegraphy has been attained by that chief marvel of this electrical age—the speaking telephone of Graham Bell. The reproduction of the human voice at a distance, restricted only by geographical limits, seems to have reached the confines of human ingenuity; and though wild enthusiasts have dreamt of reproducing objects abroad visible to the naked eye at home, no one at the present moment can say that such a thing is possible, while in face of the wonders that have been done no one dare say that it is impossible.

The commercial business of telegraphy, when our thoughts and wishes, orders and wants, could be transmitted for money, was inaugurated in this country by the establishment of the Electric Telegraph Company in 1846, and until 1870 it remained in the hands of private enterprise, when it was purchased by the Government, and placed under the sole control of the Postmaster-General. It has been the fashion to decry the terms of purchase of the various undertakings then at work by those who have not understood the question, and by those who, being politically opposed to the Government in power at the time, saw all their acts, not only through a glass darkly, but through a reversing lens. A business producing £550,000 per annum was bought at twenty years' purchase, and that business has now increased to £2,000,000 per annum. 6,000,000 messages per annum have increased to 52,000,000.

Every post-office has been made a telegraph-office, every village of any size has its wire; messages which used to cost 12*s*. 6*d*. are now sent for 6*d*.; a tariff which was vexatious from its unfair variation is now uniform over the United Kingdom, and no one can justly complain of error or delay in the transmission of their messages. Silly complaints are sometimes inserted in the Press, of errors which the most elementary knowledge of the Morse alphabet would detect, and little credit is given to the fact that the most perfect telegraph is subject to strange disturbances from terrestrial and atmospheric causes which admit sources of error beyond the control of the telegraphist. A flash of lightning in America may cause an extra dot in Europe, and *man* may become *war*. An earthquake in Japan may send a dash through France, and *life* would become *wife*. A wild goose flying against a telegraph-wire might drive it into momentary contact with another wire, and *sight* might become *night*. Everyone should know his Morse alphabet, and people should learn how to write. Nine-tenths of the errors made are due to the execrable calligraphy of the present day. As a matter of fact, in ninety-nine cases out of a hundred, the telegraphist delivers to the editor of a newspaper "copy" far more accurate than the first proof of his own leader submitted by the printer. The quantity of news transmitted is enormous: an average of 1,538,270 words are delivered per day. The recent Convention in Chicago, when the Republican party of the United States nominated their candidate for the Presidentship, created so much business that every American paper has chronicled this big thing as unique. 500,000 words were sent on one night; but we in England, when Mr. Gladstone introduced his celebrated Home Rule Bill on April 8, 1886, sent from the Central Telegraph Office in London 1,500,000 words.

The growth of business has led to vast improvement in the carrying capacity of the wires. Cooke and Wheatstone required five wires for their first needle instrument to work at the rate of four words per minute. One wire can now convey six messages at ten times the speed. The first Morse apparatus could work at about five words a minute: we now transmit news at the rate of 600 words a minute. In 1875 it was thought wonderful to transmit messages to Ireland at 80 words a minute. When I was recently in Belfast I timed messages coming at the rate of 461 words a minute. Duplex working—that is, two messages travelling on the same wire at the same time in opposite directions, the invention of Gintl, of Vienna—is now the normal mode of working; Edison's quadruplex is common; and the Delany system of multiplex working is gradually being introduced, by which six messages are indiscriminately sent in either direction. The telegraphic system of England has been brought to the highest pitch of perfection. We have neither neglected the inventions of other countries, nor have we been chary of exercising inventive skill ourselves, and we have received our full meed of that reward which is always freely bestowed on a British Government official, neglect and abuse. All parts of the civilized world are now united by submarine cables. The *Times* every morning has despatches from every quarter of the globe, giving the news of the previous day. 110,000 miles of cable have been laid by British ships, and nearly £40,000,000 of British capital have been expended by private enterprise in completing this grand undertaking. A fleet of 37 ships is maintained in various oceans to lay new cables and to repair breaks and faults as they occur—faults that arise, among other causes, from chafing on coral reefs, ships' anchors, the onslaught of insects, and earthquakes. The two cables connecting Australia and Java were recently simultaneously broken by an earthquake.

The politician, unmindful of the works of the engineer, is apt to apply to the credit of his own proceedings the growing prosperity of the world. The engineer, however, feels that steam and electricity in his hands have done more to economize labour, to cheapen life, to increase wealth, to promote international friendship, to alleviate suffering, to ward off war, to encourage peace, than all the legislation and all the verbosity of the politician.

The railways of this country are entirely dependent for the conduct of their traffic on the telegraph, and the security of their passengers is mainly due to the working of the block system. A railway—say between London and Bath—is broken up into certain short sections, and only one train is allowed on one section at one time. The presence, motion, and departure of trains are announced and controlled by electric signals, and the out-door signals are governed by these electric signals. There are few more interesting places to visit than a well-equipped signal-box on one of our main railways. The signalman is able to survey the lines all around and about him by aid of his electric signals; he can talk by telegraph or by telephone to his neighbours and his station-master; he learns of the motion of the trains he is marshalling by the different sounds of electric bells; he controls his out-door signals by the deflection of needles, or the movement of miniature semaphores; he learns the true working of his distant signals by their electrical repetition; machinery governs and locks every motion he makes, so that he cannot make a mistake. The safety of railway travelling is indicated by the fact that, while in the five years ending 1878 thirty-five people were killed annually from causes beyond their own control, in the five years ending 1887 the average has been reduced to sixteen. One person is killed in 35,000,000 journeys made by train. Wherever we are dependent on human agency we are subject to human error, and a serious accident very recently at Hampton Wick has shown how the most perfect machinery may be rendered valueless to protect life when perversity, thoughtlessness, or criminality enter as factors into the case.

At the meeting of the Association in Plymouth in 1877, I was able for the first time in this country to show the telephone at work. Since then its use has advanced with giant strides. There are probably a million instruments at work now throughout the civilized world. Its development has been regularly chronicled at our meetings. As far as the receiving part of the apparatus is concerned, it remains precisely the same as that which I brought over from America in 1877; but the transmitter, ever since the discovery of the microphone by Hughes in 1878, has been entirely remodelled. Edison's carbon transmitter was a great step in advance; but the modern transmitters of Moseley, Berliner, D'Arsonval, De Jongh, leave little to be desired. The disturbances due to induction have been entirely eliminated, and the laws regulating the distance to which speech is possible are so well known, that the specification of the circuit required to connect the Land's End with John o' Groats by telephone is a simple question of calculation. A circuit has been erected between Paris and Marseilles, 600 miles apart, with two copper wires of 6½ gauge, weighing 540 pounds per mile, and conversation is easily maintained between those important cities at the cost of three francs for three minutes. One scarcely knows which fact is the more astounding—the distance at which the human voice can be reproduced, or the ridiculously simple apparatus that performs the reproduction. But more marvellous than either is the extreme sensitiveness of the instrument itself, for the energy contained in one heat unit (gramme-water-degree) would, according to Pellat, maintain a continuous sound for 10,000 years.

The influence which electric currents exert on neighbouring wires extend to enormous distances, and communication between trains, and ships in motion, between armies inside and outside besieged cities, between islands and the main-land, has become possible without the aid of wires at all, by the induction which is exerted through space itself. On the Lehigh Valley Railway, in the United States, such a system of telegraphing without wires is in actual daily use.

The conduct of the telephonic business in England is still in the hands of those who hold the patents, and who maintain a most rigid monopoly. These patents have only a short period to run, and when they expire we may expect to find that England will not occupy the very retired position she holds now as a telephone country. Stockholm has more subscribers than London; there are 15,000 subscribers in and about New York, while the number in London is only 4851.

Electric lighting has become popular, not alone from the beauty of the light itself, but from its great hygienic qualities in maintaining the purity and coolness of the air we breathe. The electric light need not be more brilliant than gas, but it must be more healthy. It need not be cooler than a wax candle, but it must be brighter, steadier, and more pleasant to the eye. In fact, it can be rendered the most perfect artificial illuminant at our disposal, for it can illumine a room without being seen directly by the eye; it can be made absolutely steady and uniform without irritating the retina; it does not poison the air by carbonic acid and carbonic oxide, or dirty the decorations by depositing unconsumed carbon; it does not destroy books or articles of vertu and art by forming water which absorbs sulphur acids; and it does not unnecessarily heat the room.

In our Central Savings Bank in London it has been found, after two years' experience of electric lighting, that the average amount of absences from illness has been diminished by about two days a year for each person on the staff. This is equivalent to a gain to the service of the time of about eight clerks in that department alone. Taking the cost at the "overtime" rate only, this would mean a saving in salaries of about £640 a year. The cost of the installation of the electric light was £3349, and the annual cost of working £700 per annum, say a total annual cost of £1034. The cost of the gas consumed for lighting purposes was about £700 a year, so that on the whole there was a direct saving of something like £266 a year to the Government, besides the material advantage of the better work of the staff resulting from the improved atmospheric conditions under which their work is done.

The production of light by any means implies the consumption of energy, and this can be measured in *watts*, or the rate at which this energy is consumed. A watt is $\frac{1}{746}$ part of a *horse-power*. It is a very convenient and sensible unit of power, and will in time replace the meaningless horse-power.

One candle light maintained by	tallow . . .	absorbs	124 watts.
,, ,,	wax	,,	94 ,,
,, ,,	sperm . . .	,,	86 ,,
,, ,,	mineral oil .	,,	80 ,,
,, ,,	vegetable oil .	,,	57 ,,
,, ,,	coal gas . . .	,,	68 ,,
,, ,,	cannel gas . .	,,	48 ,,
,, ,,	electricity (glow)	,,	3 ,,
,, ,,	electricity (arc)	,,	55 ,,

The relative heat generation of these illuminants may be estimated from these figures.

Though the electric light was discovered by Davy in 1810, it was not until 1844 that it was introduced into our scientific laboratories by Foucault; it was not until 1878 that Jablochkoff and Brush showed how to light up our streets effectually and practically; it was not until 1881 that Edison and Swan showed how our homes could be illuminated softly and perfectly. Unpreparedness for such a revolution produced a perfect panic among gas proprietors; inexperience in the use of powerful electric currents resulted in frequent failure and danger; speculation in financial bubbles transferred much gold from the pockets of the weak to the coffers of the unscrupulous; hasty legislation in 1882 restricted the operations of the cautious and the wise; and the prejudice arising from all these causes has, perhaps fortunately, delayed the general introduction of electricity; but now legislation has been improved, experience has been gained, confidence is being restored, and in this beautiful town of Bath fifty streets are about to be lighted, and we see everywhere around and about us in our English homes the pure glow-lamp replacing filthy gas and stinking oil. The economical distribution of the electric current over large areas is annually receiving a fresh impetus. The expensive systems defined in the Act of Parliament of 1882 have entirely disappeared. Hopkinson in England, and Edison in America, showed how a third wire reduced the weight of copper needed by 66 per cent. Gaulard and Gibbs in 1882 showed how the conversion of alternate currents of high electromotive force to currents of low electromotive force by simple induction coils would enable a mere telegraph wire to convey sufficient electricity to light a distant neighbourhood economically and efficiently. Lane Fox in 1879 showed how the same thing could be done by secondary batteries; and Planté, Faure, Sellon, and Parker have done much to prove how batteries can be made to solve the problem of storage; while King and Edmunds have shown how the distribution by secondary batteries can be done as economically as by secondary generators. The Grosvenor Gallery Company in London have proved the practicability of the secondary generator principle by nightly supplying 24,000 glow-lamps scattered over a very wide area of London. The glow-lamp of Edison, which in 1881 required 5 watts per candle, has been so far improved that it now consumes but 2½ watts per candle. The dynamo, which in the same year weighed 50,000 pounds, absorbed 150 horse power, and cost £4000 for 1000 lamps, now weighs 14,000 pounds, absorbs 110 horse-power, and costs £500 for the same production of external energy; in other words, its commercial output has been increased nearly six times, while its prime cost has been diminished eight times.

The steam-engine has received equal attention. The economy of the electric light when steam is used depends almost entirely on the consumption of coal. With slow-speed low-pressure engines one kilowatt (1000 watts, 1⅓ horse-power) may consume 12 pounds of coal per hour; in high-speed high-pressure triple-expansion engines it need not consume more than 1 pound of coal per hour. Willans and Robinson have actually delivered from a dynamo one kilowatt by the consumption of 2 pounds of coal per hour, or by the condensation of 20 pounds of steam.

There is a great tendency to use small economical direct-acting engines in place of large expensive engines, which waste power in countershafting and belts. Between the energy developed in the furnace in the form of heat, and that distributed in our rooms in the form of light, there have been too many points of waste in the intermediate operations. These have now been eliminated or reduced. Electricity can now be produced by steam at 3*d.* per kilowatt per hour. The kilowatt-hour is the Board of Trade unit as defined by the Act of 1882, for which the consumer of electric energy has to pay. Its production by gas-engines costs 6*d.* per kilowatt-hour, while by primary batteries it costs 3*s.* per kilowatt-hour. The Grosvenor Gallery Company supply currents at 7½*d.* per kilowatt-hour; a 20 candle-power lamp consuming 3 watts per candle, and burning 1200 hours per annum, expends 82,000 watt-hours or 82 kilowatt-hours, and it costs, at 7½*d.* per unit, 50*s.* per annum. If the electricity be produced on the premises, as is the case in the Post Office, in the House of Commons, and in many large places, it would cost 20*s.* 6*d.* per annum. I have found from a general average under the same circumstances and for the same light in the General Post Office in London that an electric glow-lamp costs 22*s.* and a gas-lamp 18*s.* per annum. The actual cost of the production of one candle light per annum of 1000 hours is as follows:—

	s.	*d.*
Sperm candles	8	6
Gas (London)	1	3
Oil (petroleum)	0	8
Electricity (glow)	0	9
Electricity (arc)	0	1½

The greatest development of the electric light has taken place on board ship. Our Admiralty have been foremost in this work. All our warships are gradually receiving their equipment. Our ocean-going passenger ships are also now so illumined, and perhaps it is here that the comfort, security, and true blessedness of the electric light are experienced.

Railway trains are also being rapidly fitted up. The express trains to Brighton have for a long time been so lighted, and now several northern railways, notably the Midland, are following suit. Our rocky coasts and prominent landfalls are also having their lighthouses fitted with brilliant arc lamps, the last being St. Catherine's Point, on the Isle of Wight, where 60,000 candles throw their bright beams over the English Channel, causing many an anxious mariner to proceed on his way rejoicing.

Fontaine showed in Vienna, in 1873, that a dynamo was reversible—that is, if rotated by the energy of a moving machine, it would produce electric currents; or, if rotated by electric currents, it would move machinery. An electric current is one form of energy. If we have at one place the energy of falling water, we can, by means of a turbine and a dynamo, convert a certain portion of the energy of this falling water into an electric current. We transmit this current through proper conductors to any other place we like, and we can again, by means of a motor, convert the energy of the current into mechanical energy to do work by moving machinery, drawing tram-cars, or in any other way. We can in this way transmit and utilize 50 per cent. of the energy of the falling water wherever we like. The waste forces of Nature are thus within our reach. The waterfalls of Wales may be utilized in London; the torrents of the Highlands may work the tramways of Edinburgh; the wasted horse-power of Niagara may light up New York. The falls of Bushmills actually do work the tramway from Portrush to the Giant's Causeway, and those of Bessbrook the line from Newry to Bessbrook.

The practicability of the transmission of energy by currents is assured, and the economy of doing this is a mere matter of calculation. It is a question of the relative cost of the transmission of fuel in bulk, or of the transmission of energy by wire. Coal can be delivered in London for 12*s.* per ton. The mere cost of the up-keep of a wire between Wales and London to deliver the same amount of energy would exceed this sum tenfold. For long distances the transmission of energy is at present out of the question. There can be no doubt, however, that for many purposes within limited areas the transmission of energy by electricity would be very economical and effective. Pumps are worked in the mines of the Forest of Dean, cranes are moved in the works of Easton and Anderson at Erith, lifts are raised in banks in London; water is pumped up from wells to cisterns in the house of Sir Francis Truscott, near East Grinstead; ventilation is effected and temperature lowered in collieries; goods, minerals, and fuel can be transmitted by telpherage.

The transmission of power by electricity is thus within the range of practice. It can be distributed during the day by the same mains which supply currents for light by night. Small industries, such as printing, watch-making, tailoring, boot-making, can be cheaply supplied with power. It is thus brought into direct competition with the distribution of power by steam as in America, or by air-pressure as in Paris, or by high-pressure water as in London; and the relative advantages and economies of each system are simple questions of calculation. When that evil day arrives that our supply of natural fuel ceases, then we may look to electricity to bring to our aid the waste energies of Nature—the heat of the sun, the tidal wave of the ocean, the flowing river, the roaring falls, and the raging storm.

There is a mode of transport which is likely to create a revolution in the method of working tramways. A tramcar carries a set of accumulators which supplies a current to work a motor geared to a pair of wheels of the car. The weight, price, day's work, and life of the accumulator is curiously the same as the weight, price, day's work, and life of horseflesh; but the cost of maintenance, the liability to accident, and the chances of failure are much less. Although very great improvements in batteries have been made, and they are now really practical things, sufficient experience in tramcar working has not yet been obtained to say that we have reached the proper accumulator. Nor have we yet acquired the best motor and mode of gearing; but very active experiments are being carried out in various countries, and nothing can prevent their ultimate success.

The property which the electric current possesses, of doing work upon the chemical constitution of bodies so as to break up certain liquid compounds into their constituent parts, and marshal these disunited molecules in regular order, according to a definite law, upon the surfaces of metals in contact with the liquid where the current enters and exists, has led to immense industries in electro-metallurgy and electro-plating. The extent of this industry may be gathered from the fact that there are 172 electro-platers in Sheffield and 99 in Birmingham. The term electro-metallurgy was originally applied to the electro-deposition of a thin layer of one metal on another; but this is now known as electro-plating.

In 1839, Jacobi in St. Petersburg and Spencer in Liverpool laid the foundations of all we know of these interesting arts. Copper was deposited by them so as to obtain exact reproductions of coins, medals, and engraved plates. The first patents in this country and in France were taken out by Messrs. Elkington, of Birmingham, who still occupy the foremost position in the country.

The fine metals, gold and silver, are deposited in thin layers on coarser metals, such as German silver, in immense quantities. Christofle, of Paris, deposits annually six tons of silver upon articles of use and of art, and if the surfaces so electro-plated were spread out continuously they would cover 140 acres.

The whole of the copper plates used in Southampton for the production of our splendid Ordnance Survey maps are deposited by copper on matrices taken from the original engraved plates, which are thus never injured or worn, are always ready for addition or correction, while the copies may be multiplied at pleasure and renewed at will.

Nickel-plating, by which the readily oxidizable metals like iron are coated with a thin layer of the more durable material nickel, is becoming a great industry; the trappings of harness, the exposed parts of machinery, the fittings of cycles and carriages, and innumerable articles of daily use, are being rendered not only more durable but more beautiful.

The electro-deposition of iron, as devised by Jacobi and Klein, in the hands of Prof. Roberts-Austen, F.R.S., is giving very interesting results. The dies for the coins which were struck at our Mint on the occasion of the Jubilee of the Queen were modelled in plaster, reproduced in intaglio by the electro-deposition of copper, and on these copper moulds hard excellent iron in layers of nearly $\frac{1}{10}$ of an inch was deposited.

The exact processes of measurement, which have led to such vast improvement in our telegraphic systems, have scarcely yet penetrated into this field of electrical industry, and little is known at present of the exact relations of current and electromotive force with respect to surfaces of contact, rate of deposit, and resistance of liquids. Captain Sankey, R.E., of the Ordnance Survey Department, has done some useful work in this direction.

The extraction of metals from their ores by deposition has received wide application in the case of copper. In 1871, Elkington proposed to precipitate copper electrolytically from the fused sulphide of copper and iron known to the copper smelter as "regulus." Thin copper plates were arranged to receive the deposited copper, while the foreign metals, including gold and silver, fell to the bottom of the solution, the process being specially applicable, it was supposed, to regulus containing small quantities of the precious metals.

The electrical purification of copper from impure "blister copper" or "blade copper" has also made great progress, and special dynamos are now made which will, with an expenditure of 100 horse-power, precipitate 18 tons of copper per week. The impure metal is made to form the anode in a bath of sulphate of copper, the metal being deposited in the pure form on a thin copper cathode.

It was not very long ago considered very economical to absorb 0·85 horse-power in depositing 1 pound of copper per hour, but now the same work can be done with 0·3 horse-power. Mr. Parker, of Wolverhampton, has done good work in this direction, and his dynamos in Messrs. Bolton's works have revolutionized this process of purification.

Both at Swansea and Widnes, immense quantities of copper, in spite of the restrictive operations of the Copper Syndicate, are being produced by electro-deposition. Copper steam-pipes for boilers are now being built up of great firmness, fine texture, and considerable strength, by Mr. Elmore, at Cockermouth, by electro-deposition on a rotating mandril in a tank of sulphate of copper. By this process one ton of copper requires only a little more than one ton of coal to raise the requisite steam to complete the operation.

It has been shown that the electrolytic separation of silver from gold by similar methods is perfectly practicable. The value of the material to be dealt with may be gathered from the fact, communicated to the Gold and Silver Commission now sitting, that nearly 90,000,000 ounces of silver are annually produced, and the greater portion of this amount contains sufficient gold to render refining remunerative. Although the old acid process of "parting" gold and silver remains practically undisturbed, there seems no reason to doubt that in the future electricity will render us good service in this direction, as it has already in the purification of copper.

There is not much actual progress to report in the extraction of gold from its ores by electrical agency. The conversion of gold into chloride of gold by the direct, or indirect, action of chlorine is employed on a very large scale in [Grass Valley] California and elsewhere. This fact has led to well-directed efforts to obtain, by electrolytic action, chlorine which should attack finely-divided gold suspended (with the crushed ore) in the solution from which the chlorine was generated, the gold, so converted into soluble chloride, then being deposited on a cathode. The process would seem to be hopeful, but is not as yet a serious rival to the ordinary chlorination method.

In the amalgamation of gold ores much is expected from the possibility of keeping clean, by the aid of hydrogen set free by the electric current, the surfaces of amalgamated plates.

It is well known that the late Sir W. Siemens considered that the electric arc might render good service in the fusion of metals with high melting-points, and he actually succeeded in melting 96 ounces of platinum in ten minutes with his electrical furnace. The experiments were interrupted by his untimely death; but in the hands of Messrs. Cowles the electric arc produced by 5000 amperes and 500 horse-power is being employed on a very large scale for the isolation of aluminium (from corundum), which is immediately alloyed (*in situ*) with copper or iron, in the presence of which it is separated.

The heating power of large currents has been used by Elihu Thomson in the United States, and by Bernardos in Russia, to weld metals, and it is said to weld steel without affecting its hardness. It has even been proposed to weld together in one continuous metallic mass the rails of our railways, so as to dispense entirely with joints.

The production of chlorine for bleaching and of iodine for pharmaceutical purposes, the economical production of oxygen, are also processes now dependent on the electrolytic effect of the electric current.

It is almost impossible to enumerate the various general purposes to which electricity is applied to minister to our wants and to add to our comforts. Everyone appreciates the silent efficiency of the trembling electric bell, while all will sooner or later derive comfort from the perennially self-winding electric clock. Correct mean time is distributed throughout the length and breadth of the land by currents derived from Greenwich Observatory. Warehouses and shops are fitted with automatic contact pieces, which, on any undue increase of temperature due to fire, create an alarm in the nearest fire-station; and at the corner of most streets a post is found with a face of glass, which on being broken enables the passer-by or the watchful and active policeman to call a fire-engine to the exact spot of danger. Our sewers are likely to find in its active chemical agency a power to neutralize offensive gases, and to purify poisonous and dangerous fluids. The germs of diseases are attacked and destroyed in their very lairs. The physician and the surgeon trust to it to alleviate pain, to cure disease, to effect organic changes beyond the reach of drugs. The photographer finds in the brilliant rays of the arc lamp a miniature sun which enables him to pursue his lucrative business at night, or during the dark and dismal hours of a black November fog in London.

We learn from the instructive and interesting advertising columns of our newspaper that "electricity is life," and we may perhaps read in the more historical portion of the same paper that by a recent decision of the New York Parliament, "electricity is death." It is proposed to replace hanging by the more painless and sudden application of a powerful electrical charge; but those who have assisted at this hasty legislation would have done well to have assured themselves of the practical efficacy of the proposed process. I have seen the difficulty of killing even a rabbit with the most powerful induction coil ever made, and I know those who escaped and recovered from the stroke of a lightning discharge.

The fact that the energy of a current of electricity, either when it flashes across an air space, or when it is forced through high resistance, assumes the form of heat of very high temperature led early to its employment for firing charges of gunpowder; and for many civil, military, and naval purposes it has become an invaluable and essential agent. Wrecks like that of the *Royal George* at Spithead were blown up and destroyed; the faces of cliffs and quarries are thrown down; the galleries of mines and tunnels are excavated; obstructions to navigation like the famous Hell Gate, near New York, have been removed; time-guns to distribute correct time are fired by currents from Greenwich at 1 p.m. In the operations of war, both for attack and defence, submarine mining has become the most important branch of the profession of a soldier and a sailor. Big guns, whether singly or in broadside, are fired; and torpedoes, when an enemy's ship unwittingly is placed over them, are exploded by currents of electricity.

An immense amount of research has been devoted to design the best form of fuse, and the best form of generator of electricity to use to explode them. Gun tubes for firing consist of a short piece of very fine wire embedded in some easily fusible compound, while the best form of fuse is that known as the Abel fuse, which is composed of a small, compact mass of copper phosphide, copper sulphide, and potassium chlorate. The practice in the use of generators is very various. Some, like the Austrians, lean to the high-tension effects of static electricity; others prefer magneto-machines; others use the dynamo; while we in England cling with much fondness to the trustworthy battery. Since the electric light has also become such a valuable adjunct to war purposes, it is probable that secondary batteries will become of immense service. The strong inductive effects of atmospheric electricity are a source of great danger. Many accidental explosions of fuses have occurred. An experimental cable with a fuse at one end was laid below low water mark along the bank of the Thames at Woolwich. The fuse was exploded during a heavy thunderstorm. The knowledge of the causes of a danger is a sure means for the production of its removal, or of its reduction to a minimum. Low-tension fuses and metallic circuits reduce the evils of lightning, but have not removed them. Should war unhappily break out again in Europe, submarine mining will play a very serious part; and, paradoxical as it may appear—as has been suggested by the French Ambassador, M. Waddington—its very destructiveness may ultimately prove it to be a powerful element of peace.

It seems incredible that, having utilized this great power of Nature to such a wide and general extent, we should be still in a state of mental fog as to the answer to be given to the simple question—What is Electricity? The engineer and the physicist are completely at variance on this point. The engineer regards electricity, like heat, light, and sound, as a definite form of energy, something that he can generate and destroy, something that he can play with and utilize, something that he can measure and apply. The physicist—at least some physicists, for it is difficult to find any two physicists that completely agree with each other—regard electricity as a peculiar form of matter permeating all space as well as all substances, together with the luminiferous ether, which it permeates like a jelly or a sponge. Conductors, according to this theory, are holes or pipes in this jelly, and electrical generators are pumps that transfer this hypothetical matter from one place to another. Other physicists, following Edlund, regard the ether and electricity as identical; and some, the disciples of Helmholtz, consider it as an integral constituent of Nature, each molecule of matter having its own definite charge, which determines its attraction and its repulsion. All attempts to revive the Franklinian, or material, theory of electricity, have, however, to be so loaded with assumptions, and so weighted with contradictions, that they completely fail to remove electricity from the region of the mysterious. It is already extremely difficult to conceive the existence of the ether itself as an infinitely thin, highly elastic medium, filling all space, employed only as the vehicle of those undulatory motions that give us light and radiant heat. The material theory of electricity requires us to add to this another incomprehensible medium embedded or entangled in this ether, which is not only a medium for motion, but which is itself moved. The practical man, with his eye and his mind trained by the stern realities of daily experience, on a scale vast compared with that of the little world of the laboratory, revolts from such wild hypotheses, such unnecessary and inconceivable conceptions, such a travesty of the beautiful simplicity of Nature.

He has a clear conception of electricity as something which has a distinct objective existence, which he can manufacture and sell, and something which the unphilosophic and ordinary member of society can buy and use. The physicist asserts dogmatically: "Electricity may possibly be a form of matter—it is not a form of energy." The engineer says distinctly: "Electricity is a form of energy—it is not a form of matter; it obeys the two great developments of the present generation—the mechanical theory of heat and the doctrine of the conservation of energy." There must be some cause for this strange difference of views. It is clear that the physicist and the engineer do not apply the term electricity to the same thing. The engineer's electricity is a real form of energy; the speculative philosopher's electricity is a vague subjective unreality which is only a mere factor of energy and is not energy itself. This factor, like force, gravity, life, must, at any rate for the present, remain unknowable. It is not known what force is; neither do we know what is matter or gravity. The metaphysician is even doubtful as regards time and space. Our knowledge of these things commences with a definition. The human mind is so unimpressionable, or language is so poor, that writers often cannot agree even on a definition. The definition of energy is capacity for doing work. We practical men are quite content to start from this fiducial line, and to affirm that our electricity is a something which has a capacity for doing work; it is a peculiar form of energy. The physicist may speculate as much as he pleases on the other side of this line. He may take the factors of energy, and mentally play with them to his heart's content; but he must not rob the engineer of his term *electricity*. It is a pity that we cannot settle our difference by changing the term. Physicists might leave the term *electricity* to the form of energy, which is an objective reality, and which the ordinary mortal understands; while engineers would be quite content if speculative physicists and enthusiastic mathematicians would call their subjective unreality, their imaginary electrical matter, by some other term. If it be necessary to mentally create some imaginary matter to fulfil the assumptions and abstractions of their mathematical realizations, let them call it *coulombism* or *electron*, and not appropriate the engineer's generic and comprehensive term electricity. The engineer finds the motions of existing matter and of the ether quite sufficient to meet all his requirements, and to account for all those phenomena which are called electrical.

It seems paradoxical to assert that two unrealities can form a reality, or that two subjective ideas can become an objective one; but it must be remembered that in all electrical phenomena that which makes them real and objective is derived from without. The motion that renders an electrical phenomenon evident is imparted to it from some other form of energy. The doctrine of the conservation of energy asserts that energy is never destroyed, it is only transformed—work must be done to render it evident. No single electrical effect can be adduced which is not the result of work done, and is not the equivalent of energy absorbed. The engineer's notion of work—something done against resistance; and of power—the rate at which this change of condition is effected—are the key-stones to the conception of the character of those great sources of power in Nature whose direction to the uses and convenience of man is the immediate profession of those who generally assemble together in Section G of the British Association to discuss the "practical application of the most important principles of natural philosophy, which has, in a considerable degree, realized the anticipations of Bacon and changed the aspect and state of affairs in the whole world."

I cannot pretend to have given a survey of all the practical applications of electricity. I have but briefly indicated the present area covered by the new and rapidly-growing industry. Five million people upon the globe are now dependent on the electric current for their daily bread. Scarcely a week passes without some fresh practical application of its principles, and we seem to be only on the shore of that sea of economy and beneficence which expands with every new discovery of the properties of electricity, and spreads already beyond the mental grasp of any one single worker.

NOTES.

THE Geological Congress held its first meeting on Tuesday. This week we print the President's address and one of the papers referring to one of the most important points to be considered by the Congress—that of the Crystalline Schists.

INTELLIGENCE has been received of the murder of Major Barttelot, Mr. Stanley's principal lieutenant, by some of his followers when on the way from Stanley Falls with reinforcements for his chief.

THE sudden death of Mr. R. A. Proctor was announced from New York about a week ago. In addition to his writings on various subjects for which his name is so widely known, he made some contributions to the science of astronomy. Some of his books, such as "Saturn and its System," his various star atlases, and others we might name, have a permanent value. Elected a Fellow of the Royal Astronomical Society in 1866, he was for a considerable number of years the most prolific contributor to the *Monthly Notices*. In 1871 he was elected to the Council, and in the following year was appointed the Secretary. The determination of the rotation-period of Mars, a chart of Mars from the collation of a large number of drawings, a long series of papers on transits of Venus, especially the transits of 1874 and 1882, and a yet more important series on the distribution of stars and nebulæ, were communicated to the Astronomical Society during these years. It was in connection with this last series that his greatest single work for science was carried out, viz. the copying of the 324,198 stars of Argelander's "Survey of the Northern Heavens," on an "equal surface" projection chart, a work that involved 400 hours of the most unremitting labour. Mr. Proctor was born at Chelsea, in March 1834, and was educated at King's College, London, of which he was Honorary Fellow, and at St. John's College, Cambridge, where he won a Scholarship. He obtained his degree of B.A. in 1860, and his name appears as twenty-third in the Wrangler's List.

AN evening class in organic chemistry, adapted to the requirements of candidates for the second B.Sc. examination of London University, will be held at the Birkbeck Institution in Chancery Lane during the ensuing session, under the direction of Mr. Frank Gossling, B.Sc. This is said to be the first session in which an evening class of this character has been attempted.

THE *Times* publishes the following interesting letter from Sir William Thomson:—"In the *Times* of to-day (Sept. 14) I see a slight mistake regarding myself. A British Association correspondent says:—'Sir William Thomson in one paper cautiously made what must be regarded as a somewhat noteworthy admission with reference to Clerk-Maxwell's fundamental theory of electromagnetic induction for incomplete circuits. He considered Maxwell's fundamental assumption "not wholly tenable." In all his previous utterances on the subject Sir William has described Maxwell's views on this point as completely untenable.' The paper referred to by your correspondent is my very first public utterance on the subject. An uncorrected proof of it in print contained the words 'wholly untenable,' which I altered to 'not wholly tenable' in reading it to the Section. The fact is, I had always believed in the possibility and probability of Maxwell's assumption (he only gave it himself as probable or possible) until a few months ago, when I saw what seemed to me reasons for wholly discarding it; but two days of the British Association before my paper was read gave me the inestimable benefit of conversation with others occupied with the same subject, and of hearing Prof. Fitzgerald's presidential address in Section A, by which I was helped to happily modify my opinion. In your leading article of to-day I do not think you quite do justice to the British Association and its objects. Your remarks would be wholly just, and, if I may be allowed to say so, very useful criticism, if the British Association were an institution for teaching ascertained scientific results to its members, or 'an annual setting forth of scientific wares.' Its object is the advancement of science. It contributes to this object in a manner altogether peculiar to itself, by bringing together from all parts of the world persons engaged in scientific investigation, and giving them facilities for helping one another in their work, and being helped in it by what they see and hear. No one not following the course of scientific progress, generally or in some particular department, can fully understand how much of practical impulse is owing to the British Association for the contributions made in the course of the year to the scientific societies and magazines, in which achieved results of scientific investigation are recorded and published."

IN the last issue of the Transactions of the Seismological Society of Japan, Prof. Milne discusses the effects of earthquakes on animals. The records of most great earthquakes refer to the consternation of dogs, horses, cattle, and other domestic animals. Fish also are frequently affected. In the London earthquake of 1749, roach and other fish in a canal showed evident signs of confusion and fright; and sometimes after an earthquake fish rise to the surface dead and dying. During the Tokio earthquake of 1880, cats inside a house ran about trying to escape, foxes barked, and horses tried to kick down the boards confining them to their stables. There can, therefore, be no doubt that animals know something unusual and terrifying is taking place. More interesting than these are the observations showing that animals are agitated just before an earthquake. Ponies have been known to prance about their stalls, pheasants to scream, and frogs to cease croaking suddenly a little time before a shock, as if aware of its coming. The Japanese say that moles show their agitation by burrowing. Geese, pigs, and dogs appear more sensitive in this respect than other animals. After the great Calabrian earthquake it is said that the neighing of a horse, the braying of an ass, or the cackle of a goose was sufficient to cause the inhabitants to fly from their houses in expectation of a shock. Many birds are said to show their uneasiness before an earthquake by hiding their heads under their wings and behaving in an unusual manner. At the time of the Calabrian shock little fish like sand-eels (*Cirricelli*), which are usually buried in the sand, came to the top and were caught in multitudes. In South America certain quadrupeds, such as dogs, cats, and jerboas, are believed by the people to give warning of coming danger by their restlessness; sometimes immense flocks of sea-birds fly inland before an earthquake, as if alarmed by the commencement of some sub-oceanic disturbance. Before the shock of 1835 in Chili all the dogs are said to have escaped from the city of Talcahuano. The explanation offered by Prof. Milne of this apparent prescience is that some animals are sensitive to the small tremors which precede nearly all earthquakes. He has himself felt them some seconds before the actual earthquake came. The alarm of intelligent animals would then be the result of their own experience, which has taught them that small tremors are premonitory of movements more alarming. Signs of alarm days before an earthquake are probably accidental; but sometimes in volcanic districts gases have emanated from the ground prior to earthquakes, and have poisoned animals. In one case large numbers of fish were killed in this way in the Tiber, and at Follonica, on the morning of April 6, 1874, "the streets and roads were covered with dead rats and mice. In fact, it seemed as if it had rained rats. The only explanation of the phenomenon was that these animals had been destroyed by emanations of carbon dioxide."

THE Animals' Institute, which was opened this season for the reception of patients, has already more than verified its founders' fears that much suffering amongst the animals belonging to the poorer classes existed without proper surgical treatment. The gratuitous advice daily given is taken full advantage of, and the hospital accommodation for the worst cases is now too small to admit the great number of horses, dogs, cats, and other animals requiring treatment. A supplementary institution is wanted—a sanatorium in the suburbs—where cases requiring prolonged treatment can be kept. Such an addition, if the preliminary expenses were forthcoming, can, it is stated, be made quite self-supporting. The scheme is to be placed on a practical basis at a meeting to be held in the Committee-room of the Animals' Institute, 9 Kinnerton Street, Belgrave Square.

A COMMITTEE of the American Association presented a report at the last meeting on the teaching of physics in schools, which was very fully discussed by both the Mathematical and Physical Sections. The following is a summary of the recommendations:—(1) It is the opinion of the Committee that instruction in physics may begin, with profit, in what is generally known as the "grammar school." At the same time it is decidedly opposed to any general recommendation that it must begin there or in the primary school. Here, perhaps more than anywhere else, nearly everything depends upon the teacher. One who has a strong liking for and a good knowledge of physics will be tolerably certain to succeed, while another not thus equipped for the work is equally certain to fail. (2) When taught in the grammar school and by a competent teacher, it should be done mainly by and through illustrative experiments. These may be of the simplest character, involving and exhibiting some of the fundamental principles of science; and they should generally be made by the teacher, the pupils being encouraged to repeat, to vary, and to extend. (3) In any discussion of the character of instruction in physics in the high school, one fact of the utmost importance must not be lost sight of. It is that a large majority of the young people who are educated in the public schools receive their final scholastic training in the high school. Its course of study must be in harmony with this fact, such provision as may be made for those who continue their studies in college or university being merely incidental. It is important that the student should be made acquainted, if only to a limited extent, with the methods of physical investigation, and that he should be able himself to plan and carry out an attack upon some of the simpler problems of the science. It is believed that these two very desirable ends can be reached without giving an undue share of the time and energy of the pupil to the subject. Assuming the high-school course to consist of four years of three terms each, it is recommended that the study of physics should begin not earlier than the third year; that it should continue through one year, three hours a week being devoted to it, not including the time necessary for the preparation of the lesson; and that during the first two terms the work should be text-book work, accompanied by illustrative experiments performed by the instructor, and made as complete as his facilities will allow, while the last term should be devoted to simple laboratory exercises. (4) As to the requirements in physics for admission to college, it is sufficient to say that the course indicated above should be required for admission to any and all courses in the college. (5) In reference to the minimum course in physics for undergraduate students in the college, it seems important to avoid the mistake of asking too much. In many institutions, and especially where the elective system largely prevails, it is possible at present for students to receive a degree and yet be almost absolutely ignorant of the principles of physics. It is the judgment of the Committee that a knowledge of this subject constitutes one of the necessary and essential elements of a liberal education, and a minimum course of three hours per week for one year is recommended. What is usually known as the junior year is most desirable for this work, as at that time the student is sufficiently mature and has acquired the necessary training in mathematics to enable him to make the best of what he does. It is recommended that this course consist entirely of text-book and recitation work, with lectures fully and completely illustrated on the professor's table. The report is signed by T. C. Mendenhall, William A. Anthony, H. S. Corbait, and F. H. Smith.

A CORRESPONDENT of the *Times* calls attention to the new light now shown from the St. Catherine's Point Lighthouse in the Isle of Wight. Prior to May 1 of this year the light exhibited at this station was described in the Admiralty list of lights as fixed, dioptric, of the first order. That is, it was a steady light produced by means of a six-wick concentric oil-burner and refracting lenses, the intensity of the naked flame being equal to about 730 candles. At the present moment an electric light is being shown at St. Catherine's, the full-power intensity of which was recently stated by Captain Sydney Webb, the Deputy Master of the Trinity House, to be equal in illuminating power to rather more than 7,000,000 candles. Every half-minute, in fact—for the light now revolves—a mighty flash of five seconds' duration sweeps around the sea, and is visible at distances that seem incredible. To effect this improvement a commodious engine-room has been added to the establishment, containing three steam-engines of 12 horse-power each, and two magneto-electric machines of the De Meritens type. Two of the engines are intended to work for lighting purposes, the third being meant to work the fog-signal. As a precaution against break-down, everything is in duplicate at least, with an oil light in reserve at well. The only other lighthouses on the coast of England as which the light is produced by means of electricity are Souter Point, on the coast of Durham, between the mouths of the Tyne and the Wear; the South Foreland, and at the Lizard, on the Cornish coast. But the St. Catherine's light is ten times more powerful than the best of them, the one on Souter Point. It is, in fact, one of if not, as is believed, actually the most intensely brilliant light in existence, and one which the country as a maritime nation may certainly feel proud to see on its shores.

ON the 25th ult. the ascent of Mount Elburz was successfully made from the eastern side by Baron Ungern Sternberg. In notifying the event to the Tiflis Geographical Society, the Baron wrote:—"We set out at 11, and crossed the glaciers Iriktchat, Atrium, and Djelkaoughenkes, hitherto deemed impassable. At an altitude of 15,200 feet, I discovered an enormous crater. We passed three nights on the mountain at the different heights of 9000, 14,760, and 17,840 feet. At the last height we passed through a terrific snowstorm. Breathing was not attended with any great difficulty. The health of my men has been good. I descended by the southern side between Azaou and the Terek.'

THE last number of the *Mittheilungen* of the Vienna Geographical Society has an account by Dr. Svoboda, surgeon of the Austrian man-of-war *Aurora*, of a visit of that ship, in 1886, to the Nicobar Islands. This archipelago is usually divided into three groups:—(1) The northern islands, including Batti Malive and Kar Nicobar, which are thickly populated, some of them being flat and some mountainous and covered with jungle. Kar Nicobar has an extensive trade with Ceylon, Burmah, Singapore, and other places, as many as between forty and fifty vessels touching there annually; in fact, its harbour is never without a number of ships. The sole industry of the inhabitants is the manufacture of a kind of earthenware vessels, which they export to the other islands. Other articles of trade are "birds'-nest soup" and "sea-slug soup." The two other groups of islands are (2) the southern islands, including Great and Little Nicobar, and (3) the central islands, comprising Teressa, Chowra, Katchall, Bompoka, and many others. The inhabitants of these groups of islands are divided into classes by Dr. Svoboda—namely, the Shab-Dwa, the inhabitants of the coast, and the Shom-Pen, the inhabitants of the interior. The first class resemble the inhabitants of Siam and Burmah, but are, in general, lighter in colour than these latter. Both men and women are repulsive in appearance, though they are generally well formed. The men wear very long hair, and are, as a rule, weak and inactive. Visitors to the islands find it almost impossible to see the young unmarried women, so closely are they kept from the eyes of strangers. Prior to the visit of Dr. Svoboda, nothing appears to have been known of the Shom-Pen, or inhabitants of the interior. They are completely isolated from the outer world, and are very simple in their habits. The men wear the ordinary loin-cloth, and the women a short skirt, usually their own manufacture, and the only personal ornaments they have are small pieces of bamboo in their ears, and necklaces of variously coloured glass beads or ribbons many feet in length. Malaria is very prevalent in all the islands, especially in October and November, when the weather is hot and dry. Dr. Svoboda gives a short historical and geographical sketch of the islands, which now have a population of about 6000 souls. The Arabs appear to have been the earliest visitors, and Portuguese vessels used to call there frequently; indeed, many Portuguese words are in common use amongst the natives.

A PAPER was recently read before the French Academy of Sciences by M. Emile Lavasseur on the "Centenarians now living in France." The first reports collected gave the number of persons who had attained 100 years and upwards as 184, but on these being thoroughly sifted no less than 101 were struck out, leaving 83, but even of these there were no fewer than 67 who could not furnish adequate proof of their reputed age. In 16 cases, however, authentic records of birth or baptism were found, including that of a man born in Spain, and baptized August 20, 1770. His life was spent almost wholly in France. All the other centenarians were reputed to be between 100 and 105 years of age, with the exception of a widow claiming to be 112 years old. Of the 83 persons said to be centenarians women formed a large majority, the proportion being 52 women to 31 men. There were but few married couples, 6 male and 16 female celibates, 23 widowers, and 41 widows. One of the latter was Madame Rostkowski, 103 years of age. She enjoys a pension of 60 francs a month, allowed her by the French Government in consideration of her late husband's military services. More centenarians exist in the south-western departments, than in the rest of the Republic, while the basin of the Garonne—from the Pyrenees to the Puy de Dôme—contains as many as all the rest of France put together. M. Lavasseur finds that the chances of a person in the nineteenth century reaching 100 years of age are one in 18,800.

IN a recent number of *La Nature* Colonel Hennebert, of the Belgian army, describes underground forts which have come into use in Belgium, as one of the principal methods of national defence. One of these underground forts is like an enlarged mole-hill, and is built of concrete. Measuring 50 metres in length by from 30 to 40 in width, it is about 12 metres below the surface of the ground, and its greatest height above the earth is no more than 3 or 4 metres. It presents the appearance of an elliptical cap placed on the ground, and is scarcely visible to the eye of an observer. At the centre of this artificial rock are three armoured towers, each with two heavy guns. There are also four small forts, which are pulled in and run out at pleasure, each armed with two rapid-firing guns. At three suitable places there are armoured points of observation, from two of which at night the electric light can be flashed to watch the operations of the enemy. Below this surface the earth is hollowed out in the form of a huge well with armoured sides, which is divided up into sections, each part protected with heavy armour, one part for provisions and ammunition, another for machinery, which includes the dynamos and accumulators for the lighting of the whole fort, hydraulic machines for working the movable turrets and sending them ammunition, pumps for supplying these machines with water, and a series of ventilators to keep the air pure. Communication with the outer world is made by a subterranean gallery, the length of which varies according to surrounding circumstances. The ceiling of this gallery is from 8 to 10 metres below the surface. To gain access to the fort an hydraulic piston is worked, and this raises a ladder which runs along the whole length of the fort, and lowers the door of the outlet, which is protected by armour 20 centimetres in thickness, and is under the fire of two of the movable forts. All movements, such as changes of guard, arrivals of supplies, &c., are reported by telephone or telegraph. The guard does not work the hydraulic piston, except at command, and when the sentries in one of the movable forts have reconnoitred the visitors. Finally, the gallery communicating with the outer world is strongly fortified by an armoured door defended by two mitrailleuses. One of the greatest objections by generals to forts, that they absorb numbers of men who are wanted in the field, cannot be urged against these subterranean forts, for the garrison consists of thirty or forty mechanics and specialists only, whose absence would not appreciably weaken the regiment from which they are drawn. The cost of one of these forts is only about £100,000.

A CORRESPONDENT of the *Times* gives an interesting description of the Brünig Railway, which has recently been opened between Lucerne and Bernese Oberland. The gradient is in places very steep, being as much as 1 in 8; and on this account special precautions had to be taken both in the up and the down journeys. Generally speaking, the Rigi system has been adopted. The locomotive turns a cog-wheel which runs on a toothed rack placed between the rails, and so the train slowly travels, or rather is dragged, up hill. The cog-wheel is stopped and the engine works in the ordinary way when a moderate gradient or a level piece is met with. To check the too rapid descent of the train, the engine is fitted with a pneumatic counter-pressure action brake, which of itself is sufficient to stop the train. Besides this, each vehicle in the train is fitted up with a cog-wheel and rack similar to those used in the ascent, with drums on the axle to which clip-brakes are applied. By these appliances the speed can be regulated and the train stopped at any moment. There was another danger, however, incident to all steep railways, to be encountered—namely, the risk to the couplings during an ascent. Though the brakes on each vehicle would probably be sufficient in such a case, yet it was thought fit to take further precautions. When the train is at rest, the brake is kept fully applied by heavy weights. These weights are lifted by steam-power, which is conveyed from the engine in flexible tubes. If a coupling breaks, the flexible tube conveying the steam also breaks, and the weights fall down automatically and check the motion of the carriages. It only remains to say that the gauge is a very narrow one, being only 1 metre.

THE *American Meteorological Journal* for August contains:—(1) An article by C. C. McCaul, on the climatic effects of the Chinook wind in South Alberta, the country of the great cattle ranges in Canada, extending from lat. 49° to the Red Deer River to the northwards, and from the Rocky Mountains, on the west, to about 140 miles east. The Chinook wind blows from west to south-west, in varying degrees of strength; and the thermometer often rises in a few hours from 20° below to 40° above zero, while the snow, which may have been a foot deep in the morning, disappears before night. (2) A sketch of Prof. Abbe's work, with a portrait. He was appointed to the Weather Bureau at Washington in January 1871, and at once urged the desirability of establishing the State weather services which now form so important a part of the policy of the Signal Service. Among the many recommendations of Prof. Abbe we may mention the establishment of a "Scientific and Study Division," which was formed early in 1881, and the compilation of a Meteorological Bibliography which, although still unpublished, has grown to considerable dimensions. (3) Mr. A. L. Rotch continues his description of the meteorological service in Switzerland.

WE have received from Dr. G. Hellmann, of the German Meteorological Office, an account of the torrential rainfall of August 2 to 3 last, which caused disastrous inundations of some of the Silesian tributaries of the Oder. The storm lasted from 15 to 18 hours, during which time nearly 8 inches of rain fell over a large district, and more or less affected Galicia, Bohemia, and Poland. These heavy rains do not seem to have been caused by the same storm which gave us 1¼ inch of rain in London, on August 1 to 2, but by a distinct subsidiary depression which gradually formed over Germany on the 2nd, and moved away towards the Baltic.

MESSRS. SWAN SONNENSCHEIN AND CO. have the following works on natural history and science in the press:—"The Nature of Harmony and Metre," by Moritz Hauptmann, translated and edited by W. E. Heathcote, M.A.; "Atlas of Fossil Conchology," being the original steel plates in Brown's "Fossil Conchology," with descriptive letterpress; "The Naturalist in Siluria," by Captain Mayne Reid, illustrated; "Land and Fresh-Water Shells," by Dr. J. W. Williams; "An Introduction to Zoology," by B. Lindsay; "The Wanderings of Plants and Animals," by Prof. Victor Hehn, edited by J. S. Stallybrass.

THE additions to the Zoological Society's Gardens during the past week include two Central American Agoutis (*Dasyprocta isthmica*), obtained by purchase; a Large Hill Mynah (*Gracula intermedia*) from India, presented by Lieut.-Col. R. Thompson; a White-backed Piping Crow (*Gymnorhina leuconota*) from

Australia, presented by Mr. R. Hall; two White-fronted Amazons (*Chrysotis leucocephala*) from Cuba, a Prince Albert's Curassow (*Crax alberti*) from Columbia, a Mexican Guan (*Penelope purpurascens*), obtained by purchase; a Herring Gull (*Larus argentatus*), British, presented by the Marchioness of Cholmondeley; a Tuberculated Iguana (*Iguana tuberculata*) from Brazil, presented by Mr. H. E. Blandford; a Chameleon (*Chamæleon vulgaris*), three Lacertine Snakes (*Cœlopeltis lacertina*), and two Horseshoe Snakes (*Zamenis hippocrepis*) from Morocco, presented by Mr. Herbert E. White.

OUR ASTRONOMICAL COLUMN.

COMET 1888 *c* (BROOKS).—Dr. H. Kreutz has more recently computed for this comet more exact elements than those which he had obtained from the observations of August 9, 10, and 11. These later elements are based on observations made at Vienna on August 9, at Hamburg, August 14 and 24, and at Strassburg, August 19; aberration and parallax being corrected for.

$$T = 1888 \text{ July } 31\cdot25115, \text{ Berlin M.T.}$$

$$\left.\begin{aligned} \omega &= 59^\circ\ 19'\ 2''\cdot5 \\ \Omega &= 101\ 32\ 50\cdot1 \\ i &= 74\ 12\ 13\cdot7 \end{aligned}\right\} \text{Mean Eq. } 1888\cdot0.$$

$$\log q = 9\cdot955456$$

Error of middle places (O − C),

$$\text{August } 14 \ \ldots \ \Delta\lambda \cos\beta = -3''\cdot5\,;\ \Delta\beta = -3''\cdot2$$
$$19 \qquad\qquad +3\cdot3\,; \qquad -3\cdot4$$

Prof. A. Krueger (*Astr. Nach.*, No. 2855) has computed the following ephemeris for Berlin midnight from the foregoing:—

1888.	R.A. h. m. s.	Decl. ° '	Log *r*.	Log Δ.	Brightness.
Sept. 21	14 57 40	21 13·7 N.	0·1084	0·2310	0·45
23	15 5 34	19 44·1			
25	15 13 7	18 16·4	0·1242	0·2456	0·39
27	15 20 22	16 51·0			
29	15 27 19	15 27·9 N.	0·1395	0·2611	0·34

The brightness on August 9 is taken as unity.

On August 11 the comet was observed at the Observatory of Algiers, and the nucleus was estimated as being about equal in brightness to a star of the tenth magnitude; the nebulosity was about 1' in diameter, and there was a faint tail in the direction of the diurnal movement. Prof. L. Boss, observing the comet at Albany, N.Y., estimated it on August 10 as of mag. 9, and on August 19, in bright moonlight, as mag. 11. The tail on August 10 was estimated as 10' in length, and was of the same breadth as the head.

DISCOVERY OF A NEW COMET, 1888 *e*.—Mr. E. E. Barnard, formerly of Nashville, Tennessee, now at the Lick Observatory, discovered a new comet on September 3 at 0h. 33m. G.M.T., R.A. 6h. 52m. 16s., Decl. 10° 59' N. The comet is described as circular, 1' in diameter, of the eleventh magnitude, with tolerably well-defined nucleus, but with no tail. Dr. Kobold observed it at Strassburg on September 5 at 13h. 44·1m. G.M.T., R.A. 6h. 52m. 1·5s., Decl. 10° 49' 33" N.

COMET 1888 *d* (FAYE).—Placing the perihelion passage of this comet as 2·60d. later than given in Dr. Möller's elements, an alteration according well with the observations at Nice, August 9-17, Dr. H. Kreutz has computed (*Astr. Nach.*, No. 2856) the following ephemeris for it for Berlin midnight:—

1888.	R.A. h. m. s.	Decl. ° '	Log *r*.	Log Δ.	Brightness.
Sept. 21	6 47 41	15 36 N.	0·2472	0·2244	1·33
23	6 51 59	15 16			
25	6 56 12	14 56	0·2489	0·2177	1·36
27	7 0 21	14 35			
29	7 4 24	14 14 N.	0·2509	0·2110	1·39

The brightness on August 9 is taken as unity.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1888 *SEPTEMBER* 23-29.

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

At Greenwich on September 23

Sun rises, 5h. 50m.; souths, 11h. 52m. 6·7s.; sets, 17h. 54m.: right asc. on meridian, 12h. 3·1m.; decl. 0° 20' S. Sidereal Time at Sunset, 18h. 6m.

Moon (at Last Quarter September 28, 9h.) rises, 19h. 18m.*; souths, 2h. 0m.; sets, 8h. 54m.: right asc. on meridian, 2h. 9·5m.; decl. 7° 44' S.

Planet.	Rises. h. m.	Souths. h. m.	Sets. h. m.	Right asc. on meridian. h. m.	Declination on meridian. ° '
Mercury..	7 56	13 10	18 24	13 21·0	9 53 S.
Venus ...	7 42	13 7	18 32	13 18·2	7 30 S.
Mars ...	12 21	16 15	20 9	16 26·9	23 20 S.
Jupiter ...	11 33	15 48	20 3	15 59·3	19 59 S.
Saturn ...	1 34	9 6	16 38	9 16·4	16 40 N.
Uranus...	7 18	12 51	18 24	13 2·0	5 57 S.
Neptune..	20 5*	3 52	11 39	4 2·0	18 57 N.

* Indicates that the rising is that of the preceding evening.

Occultation of Star by the Moon (visible at Greenwich).

Sept.	Star.	Mag.	Disap. h. m.	Reap. h. m.	Corresponding angles from vertex to right for inverted image. ° °
28	ζ^2 Geminorum...	4	22 20	23 11	55 245

Sept.	h.	
23	22	Mercury at greatest distance from the Sun.

Variable Stars.

Star.	R.A. h. m.	Decl. ° '		h. m.	
U Cephei	0 52·4	81 16 N.	Sept. 26,	4 33	*m*
ζ Geminorum ...	6 57·5	20 44 N.	,, 24,	0 0	*M*
			,, 29,	4 0	*m*
T Ursæ Majoris ...	12 31·3	60 6 N.	,, 28,		*m*
R Boötis	14 32·3	27 13 N.	,, 27,		*m*
δ Libræ	14 55·0	8 4 S.	,, 27,	20 24	*m*
U Coronæ	15 13·6	32 3 N.	,, 29,	20 31	*m*
U Ophiuchi ...	17 10·9	1 20 N.	,, 25,	20 34	*m*
Z Sagittarii	18 14·8	18 55 S.	,, 24,	19 0	*M*
β Lyræ	18 46·0	33 14 N.	,, 24,	2 0	*M*
S Sagittæ	19 50·9	16 20 N.	,, 27,	21 0	*m*
X Cygni	20 39·0	35 11 N.	,, 29,	5 0	*m*
T Vulpeculæ ...	20 46·7	27 50 N.	,, 28,	19 0	*M*
			,, 29,	20 0	*m*
Y Cygni	20 47·6	34 14 N.	,, 23,	3 18	*m*
			,, 26,	3 12	*m*
δ Cephei	22 25·0	57 51 N.	,, 27,	3 0	*M*

M signifies maximum; *m* minimum.

Meteor-Showers.

	R.A. °	Decl. °	
Near α Arietis	30	18 N.	
	105	50 N.	Very swift.
,, δ Draconis	290	70 N.	Swift.

THE INTERNATIONAL GEOLOGICAL CONGRESS.[1]

I DEEPLY regret that, in consequence of his state of health, Prof. Huxley is unable to be present to-day to bid you welcome to England. But if one voice is here wanting, let me assu e you that the unanimous voice of English geologists unites in the same sentiment, and also thanks you, gentlemen, our foreign colleagues, for having responded in a manner so flattering to the invitation of English geologists to meet this year in London. For in this assembly there are representative geologists from Germany, Austria, Belgium, Denmark, Spain, France, Holland, Hungary, Italy, Norway, Portugal, Roumania, Russia, Sweden, Swizerland, as well as from the United States, Canada, Mexico, the West Indies, the Argentine Republic, and Australasia. From all these countries eminent and illustrious men honour us with their presence, and are here to aid us by their

[1] Inaugural Address delivered by P.of. J. Prestwich, President of the Congress, on Se.tember 17, 1888. (Translated from the French.)

knowledge in the discussion of the questions brought before the International Congress. The number of geologists present on this its fourth meeting indicates the continued and deep interest that they take in it.

Among the more permanent officers are the Secretaries of the Congress and of its Committees to whose important and gratuitous services we are so deeply indebted. We have unfortunately to deplore the untimely death of one amongst them—M. Charles Fontannes—and we lose on this occasion the benefit of his long experience and valuable aid.

According to custom, our discussions are, as in the diplomatic world, held in French; but it is to be hoped that the *entente cordiale* will be better maintained than it sometimes is in the other case, where such councils have not always succeeded in avoiding strife. If I may be permitted to speak after an experience of half a century, an *entente* of the most cordial character between us English geologists and our colleagues and friends abroad has been during these long years the normal condition. May these friendly and loyal relations prove a legacy to our science for all time. These friendly meetings were, however, only occasional, so that the opportunities for personal interchange of ideas were few. But more lately, instead of discussing unsettled questions, each nationality apart, the happy idea arose of submitting certain questions, which concern us all, to the arbitration of this General Council. In this manner the different national centres of our science, which have each their local colouring and their special experience, are enabled to combine the results arrived at in a wider and more uniform manner than if each apart worked out its ideas, based necessarily on more restricted observations. Nevertheless, in giving to our science the uniformity of terms and of classification which is so necessary, care must be taken not to draw lines too tight, such as, instead of developing, might retard its progress. It is desirable that these lines should be so elastic as to adjust themselves to the rapid development we have reason to expect in geological science. It is highly necessary that we should agree upon the colours and symbols to be used for the different strata, rocks, and disturbances that the terrestrial crust presents to us, but petrology is still far from being placed on firm foundations, and the synchronism of the beds, even between near countries, is not always easy to determine with exactitude, and still less between distant countries. Let us then try to avoid that error of Congresses—of arrogating an infallibility which is little in accordance with the progress of science.

Let me now say a few words upon what the Congress has already accomplished, and on what remains to be done.

At Bologna, Prof. Capellini gave the history of the Congress so fully that there is no need that I should speak of it unless it be to remind you that the idea of the Congress originated in America at the Exhibition of Philadelphia in 1876, and doubtless this idea, as well as that of the Exhibition itself, was only the expression of a desire that had been very generally felt for some time, to treat certain questions of science and art, not only, so to speak, in a national family reunion, but in a cosmopolitan reunion—to treat the great questions that concern all humanity, as belonging to the whole civilized world, and for the purposes of discussion, to make of the various nationalities a brotherhood, established on their common interests and their common weal.

The Paris Congress.—At the first Congress, which met in Paris in 1878, the primary questions of nomenclature and of classification were sketched out, as well as the unification of geological works with regard to colours and figures, so that in all countries their signification should be the same. A proposal, which was at first well received, was to make use of the solar spectrum, and to adopt the three primary colours—red, blue, and yellow—for the three divisions of the first rank of Primary, Secondary, and Tertiary rocks; that the subdivisions of the second order should be distinguished by shades of these colours, and those of the third order by hatchings of these same colours. But subsequently this scale was found to be too restricted, and at Bologna and Berlin several modifications and complementary colours were introduced, although always retaining to a certain degree the original idea. As a corollary it has been suggested that the labels of fossils should, as has already been done in several Museums, be of the same colour as that used for the strata from which they come, and that thus one would at a glance see the horizon and age of the fossil.

As to the question of unification of nomenclature for the great divisions of the earth's crust, it was felt that it is in the first place essential that there should be perfect agreement about the terms in use, and therefore that a dictionary of geology comprising the etymology or the origin of each geological name, its synonym in other languages, a definition in French, and a demonstrative figure after the manner of technological dictionaries, would be of very great use. The publication of such a work, which ought to be in at least six languages, was strongly supported. Finally, the consideration of the foregoing questions was referred to the International Commissions to report upon to the meeting of the Bologna Congress.

With regard to the classification of the strata, memoirs were received upon the Pre-Cambrian rocks, and on the nomenclature of the Palæozoic strata of North America; on the limits of the Carboniferous and Permian in various parts of Europe and in America; on the relations of the zones of extinct Vertebrates in North America and in Europe; these two last memoirs being accompanied by valuable lists of Invertebrates, plants, and reptiles of different countries. These memoirs raised very important stratigraphical and palæontological questions with regard to the wide distribution of families and of genera. Each of the faunas of the primary divisions of geological periods has been in part recognized as occurring at the same time in the two continents—in Europe and in North America: and Prof. Cope has been led to inquire whether the organic types proceed from a special centre from which they have spread; or whether the same types of generic structure have appeared independently at different points of the surface of the globe; and if so, whether they are contemporary or of varying periods. These synchronous appearances form a subject full of mystery, from whatsoever side they may be viewed. The geological record is at present too incomplete for the problem to be solved. In each country there are gaps that can only be filled by aid of continued observations in the other parts of the world. One of the most useful functions of the Congress is to encourage these.

The classification of Quaternary deposits was also discussed in relation to the remarkable history of the caves of Central France; the glacial deposits and dunes of Holland; the Tertiary beds of Portugal, which are limited to the Miocene and Pliocene; the Tertiary eruptive rocks of Hungary, viewed as to whether there is not a certain relation between the mineralogical constitution and the relative age of the various trachytic types.

The Congress was also occupied with some high physical questions, such as those of the deformations and fractures of the earth's crust; the strike and dip of faults and of chains of mountains; the origin of volcanoes, and the probable causes of great earthquakes; the structure of the Alps, and the folds of the Chalk.

Less in connection with the fundamental objects of the Congress, but having nevertheless an interest of their own, were the memoirs on the feldspars, on the alteration of the superficial deposits, on the use of the polarizing microscope, on the conductivity of heat in rocks, and other special subjects.

The Bologna Congress.—In the handsome volume of the Proceedings of the Session at Bologna, will be found the Report of the International Jury appointed to judge the competing memoirs on the unification of colours and geological signs, towards which the King of Italy generously gave 5000 francs to be awarded to the best memoir considered practically applicable. Six memoirs were received, of which the three selected for the award are published with coloured illustrations which leave nothing to be desired. The authors of these papers were of opinion that although the solar spectrum offers a very advantageous fixed base, the scale of colours is insufficient, and that it would be necessary to introduce complementary colours, or those having relation to the primary colours. The divisions, in short, of the sedimentary strata are so numerous that it will be necessary, not only to employ those colours, but also several shades of the same, or different hatchings, in reserving rose colour for the crystalline Archæan schists. For the eruptive rocks, they all agreed to use dark and bright tints of red, green, and purple, the intensity of which will render them to be readily distinguishable from the primary colours of the sedimentary rocks and from the clear colour of the schists. It was attempted to distinguish the acid and basic rocks, both with respect to their petrological composition and their age, by the use of different tints of the same colours in coloured dots, or by hatchings of various patterns, and with the letters of the Greek alphabet. Thus it is proposed to show by signs the principal varieties of granitic, porphyritic, trachytic, andesitic, and basaltic rocks, &c.; but the varieties are so numerous that one hardly knows where to draw the limits; according to one plan, the use of seventy-six signs and hatchings would be required. You will be able to judge of the various methods proposed by the fine plates which illustrate the Reports. The sections given of some of the mountains of Switzerland, and others which serve as specimens, have an excellent effect. Conventional signs are also made use of to indicate the strike and dip of the strata, faults, fossiliferous localities, sources of cold, thermal, and mineral springs, travertines, quarries, mines, &c. A geological map will thus be a veritable hieroglyphic chapter, with a universal signification.

As a result of the discussions at Bologna, and with a view to a practical application, it was decided to publish a geological map of Europe on the scale of 1/1,500,000, in which the scale of colours used would be that definitely adopted by the Congress. This map, of which the execution is well advanced, is under the direction of a Committee at Berlin.

With respect to the unification of geological terms, Reports were received from nine National Committees, viz. from Austria, Belgium, Spain, Portugal, France, Great Britain, Hungary, Italy, Russia, and Switzerland. Besides these, eleven have been received from individual members. It can be well imagined that with so many opinions they were not all in agreement, but with the good will shown by everyone, although there were differences on points of detail, they were almost unanimous on the essential points, and a preliminary general agreement was arrived at for the stratigraphical terms, such as system, group, series, stage; and for chronological terms, such as era, epoch, age, &c., leaving to future Congresses the consideration of certain subordinate points. This subject reminds me, gentlemen, of a difficult question which has yet to be faced. If your resolutions are carried by the votes of all the members of Congress, the result must be affected by the varying number of the nationalities in the changing places of meeting. For example, at Bologna there were 149 Italian members and 19 English; at Berlin there were 163 Germans and 11 English; here, on the contrary, we are . . . English and . . . foreign geologists. Therefore, if all vote, the opinion of the seat of the Congress may too much preponderate unless you find means of placing some limits upon it.

Thanks to the loyalty of the Bologna Council, the greater number of the resolutions were carried unanimously, a few only were referred to various Committees for future consideration.

With respect to the stratigraphical divisions it was resolved:—(1) That the term "group" should be applied to each of the great divisions of Primary, Secondary, and Tertiary rocks. (2) That the subdivisions of these groups should be named "systems." You have thus a Primary or Palæozoic group, and the Silurian system, the Jurassic system. (3) As to the divisions of first order of the systems, the term "series" was applied (the Oolitic series); to those of the second order, the term "stage" (the Bajocian stage); and to those of the third order the word "zone" (the zone of *Ammonites humphresianus*). The unity of the stratified masses is the stratum or bed. With regard to a word much in use in England, and dating from the primary period of geology—the word "formation," the majority of the Congress decided not to employ it in the sense of *terrain* in French, as we do, but only in the sense of origin or mode of formation, and so on. It is necessary, therefore, to seek some word to replace with us the familiar terms of "Chalk formation," "London Clay," &c.

For the chronological divisions corresponding with the stratigraphical, it was proposed that (1) "era" should correspond with "group," as the Primary era, the Secondary era; (2) "period" with "system," as the Silurian period, the Cretaceous period; (3) "epoch" with "series," as the Lower Oolitic epoch, the Lower Cretaceous epoch; "age" with "bed," as the Portlandian age, the Bathonian age, &c.

On the subject of colours and signs, the final decision was remitted to the Committee of the Geological Map; and with regard to the rules to be followed in the nomenclature of species, it was resolved that the name attached to each genus and to each species should be that by which they have been earliest known, on the condition that the characters of the genus and species have been published and clearly defined. The priority not to date beyond Linnæus, twelfth edition, 1766.

There were only four special and local memoirs presented to the Congress at Bologna, and these were in support of collections and documents exhibited.

THE BERLIN CONGRESS.—The official Proceedings of this session having only been issued during the last few days, were not available when this address was prepared. I have therefore had recourse for information to the independent notices of Messrs. Renevier, Klebs, Choffat, Frazer, Blanford, and Dewalque. At Berlin, special attention was given to the construction of the geological map, of which the Committee, profiting by the liberty given to it by the Bologna Congress, revised the colours for the sedimentary series in the following manner:—

1. Recent deposits (Alluvium, &c.)	Very pale cream colour.
2. Quaternary (Diluvium)	Naples yellow.
3. Tertiary	Various shades of yellow.
4. Cretaceous	Green tints and hatchings.
5. Jurassic	Blue tints.
6. Triassic	Violet tints and dots.
7. Permian and Carboniferous ...	Gray tints and hatchings.
8. Devonian	Brown tints.
9. Silurian	Grayish-green tints.
10. Archæan	Rose tints.

And for the ten divisions of eruptive rocks, various brilliant and dark red tints and points.

In the use of monograms to accentuate the tints, it was decided to employ Latin initials for the sedimentary deposits, and Greek initials for the eruptive rocks.

It is on this plan that the large and grand geological map of Europe in course of execution at Berlin is to be coloured, and of which the publication will realize one of the principal practical objects of the Congress—the unification of the colours employed in geology.

As to stratigraphical unification, the Congress adopted, for the most part, the resolutions passed at Bologna. But the French and Portuguese Committees proposed to substitute the term "series" for "group" in the first and third great divisions of sedimentary strata; thus, instead of Primary group, Secondary group, &c., it will be Primary series, Secondary series, &c. The word "group" will then take the place of divisions of systems, such as Oolitic group instead of series. This replacement will perhaps recommend itself to many of us.

Further, the Committees were not unanimous on the proposition to substitute, for the various existing terminations of systems, homophone terminations in *ic*. Instead of speaking of the Eocene, Cretaceous, Carboniferous, Silurian, &c., system, it was proposed to use the terms Eocenic, Cretacic, Carbonic, Siluric, &c., system. Is it essential thus to change the ancient ensigns of our science? Etymology is lost, and signification destroyed. It is well to have these terminations for things positive, such as the crystalline and eruptive rocks—for example, granitic rocks, porphyritic rocks, basaltic rocks—for here it indicates their characters; but can we subject, or is it needful to subject, several series of deposits that have no character in common to the same rigid rule, from the circumstance that they all come under the same ideal classificatory name? This question will be discussed, and it is for you, gentlemen, to judge what solution may be the most advisable.

Among other subjects, gentlemen, that you will have to consider, is that of the classification of the Cambrian and Silurian strata. According as these two great systems have been taken in descending or ascending order, the boundary between the two has been placed lower or higher, because the discordances between the series are rare, and the palæontological chain between the two systems is but little interrupted. In England, Sedgwick, who commenced from below, found himself stopped by no discordance until he reached the Mayhill Sandstone, whereas Murchison, who commenced from above, saw no reason to stop until Palæozoic life failed him; he hesitated, therefore, where to place his base line. In the same way, in those countries where they followed Murchison, whose classification was better known, the stratigraphical barriers were, according to the partisans of the one, passed over; whilst, according to the partisans of the other, there was an absence of palæontological proofs. In this country—their native stratigraphical country—the Cambrian and Silurian occupy comparatively a small area; and it is only since the death of their founders that the palæontological proofs have been increased to an extent sufficient to bring out clearly their distinctive characters. These two systems are found elsewhere (especially in America, where it is a question whether they should be associated with a Taconic system), either better developed, or with special characters which may help to determine more precisely their mutual relations. It is here, again, gentlemen, that the knowledge that you bring from many parts of the world may aid us in throwing light on this difficult subject.

Among the other questions which preceding Congresses have not decided, are :—

(1) The relation between the Carboniferous and the Permian.
(2) Between the Rhætic and the Jurassic.
(3) Between the Tertiary and the Quaternary.

When there is no interruption in the continuity of the strata, and no discordant stratification, the systems pass one into another without apparent break, like the colours of the solar spectrum; but, as you all know, if one link is wanting, the chain is broken, and the line of separation of the disunited beds becomes sharply defined. If, for example, the Caradoc should be absent in the Cambrian-Silurian, or the Pliocene should be wanting in the Tertiary, there would be between these systems a break which would give the necessary relief to the superimposed strata. The primary colours of the spectrum are not less distinctive because they pass one into the other with intermediate shades ; nor does it follow that, because there are passage-beds, the systems form one whole. There must be, somewhere, passage-beds between them, as there are between the colours.

Apart from these international questions, the Berlin Congress was occupied with several special memoirs, but we are yet without particulars, and besides, whatever may be their interest, they concern us less for the moment than international questions. Among others of the latter, a great palæontological project has been mooted, and the Congress has appointed a Commission of distinguished palæontologists to co-operate towards its realization. A work is proposed, on the plan of the "Enumerator et Nomenclator" of Brown, and of the "Prodrome" of Alcide d'Orbigny ; but such is the progress that palæontology has made, that at present, for the enumeration of all the known fossils, of animals as well as plants, a publication of some fifteen large volumes would be required. A work of this kind will make a handsome pendant to the large polyglot dictionary of geological terms, projected at Bologna.

Such, gentlemen, are some of the questions and subjects that you have to consider. You have to revise and to settle, when possible, questions already discussed, and also to discuss new problems. Among the latter there is especially the fundamental question of the crystalline schists—a subject remarkable for the great progress that it has made during the last few years, and the entirely new aspect that it is assuming ; for it is evident at present that it is not only a chemical question of metamorphism by heat, but that it is a subject which entails questions of weight, pressure, and motion, which necessitate a wide co-operation, and the combined efforts of the physicist, the chemist, the petrologist, and the stratigraphist.

Although the greater number of the subjects considered by the Congress are eminently practical and positive, they also include theoretical questions of the highest interest. The classification of the strata and their synchronism over great areas, which you have to determine, rest both upon stratigraphy and upon palæontology. In order to adjust their precise relation, you have to note the identities as well as the differences of fossil species, and to know if the order of the beds in distant countries follows a synchronous order or is only homotaxial. In the one case, we can hardly expect to find similar species ; in the other, the identity of species may be taken as a proof to the contrary, unless it may be supposed, as Edward Forbes thought, that species have had more than one centre of origin.

To solve these problems you have to trace the dawn of life, the appearance, the duration, and the disappearance of species, and the source from which they come. Are we to believe in the evolution of species, or are we to regard them as shoots of short duration, and the genera or families as the branches or permanent trunks? If I have ventured to touch upon these problems of fact and theory, it is not to express an opinion, but merely to point out how vast the field is, and how many fellow-labourers and how long is the time required to make all the necessary studies.

It must not be thought that when the fundamental questions of fact are determined the work of the Congress approaches completion. General agreement on these international questions will only smooth the way, and one can foresee in the cosmopolitan problems of theory already considered, and in many others that cannot fail to arise, what will occupy in a long and useful future all the efforts of this International Congress.

ON THE CONSTITUTION AND STRUCTURE OF THE CRYSTALLINE SCHISTS OF THE WESTERN ALPS.[1]

TEN years have elapsed since Prof. Lory first formulated his views on the crystalline schists of the Western Alps, at the Congrès International de Géologie held in Paris in 1878. These he subsequently developed at the Réunion de la Société Géologique de France at Grenoble in 1881. Since then further work in the field has strikingly confirmed these views, and Prof. Lory has taken advantage of the opportunity given by the invitation of the Organizing Committee of the Geological Congress to summarize briefly the more important facts, derived from the study of the Western Alps, that have a direct bearing on the general question of the crystalline schists.

The crystalline schists appear in the Alps in *massifs* of greater or less extent, protruding through the sedimentary formations. These *massifs* are distributed in two principal zones, arched in agreement with the general curvature of the Alps. These the author proposes to designate *the first Alpine zone*, or *Mont-Blanc zone*, and *the fourth Alpine zone*, or *Monte-Rosa zone*. The intermediate zones (*second* and *third Alpine zones*) are of less importance, the outcrops being rare and of small extent. As they resemble *the fourth zone* in their principal characters, they are treated in its connection.

(1) The *fourth Alpine zone*, or *zone of Monte-Rosa*, is by far the largest. In it the crystalline schists are exposed over the greater part of the Italian slopes, and skirt the plain from Cuneo to Lake Maggiore. Their stratification is often nearly horizontal, and always conformable with the sedimentary formations (Trias or Jura) resting upon them.

It is subsequent to the deposition of these Secondary rocks and, very probably, even much later—in Tertiary times—that this part of the Alps has been fashioned into mountains by the lateral pressure resulting from the gradual subsidence of the vast regions represented by the plains of Italy and the basin of the Adriatic. The result of these important dynamic processes was the formation of a complex of great folds, which are often much complicated by faulting.

The succession of the different groups of crystalline schists in this zone is conformable to the order indicated, long since, by Cordier. It is necessary to point out, however, that this upper group—that of the *talcites* (talc-schists)—contains talc only as an accessory constituent ; the unctuous (talcoid) aspect being due, in reality, to the presence of certain indistinctly cleavable and fibrous varieties of mica, especially sericite. These schists may be termed sericite-schists or, abbreviated, serischists. In the purer varieties they are of a nacreous white or clear gray colour ; but by the addition of chlorite they assume greenish tints and pass into chloritic and quartzose schists—the chloritoschists which attain so great a development in the whole of the Western Alps. Alternating frequently with these rocks are hornblendic schists, of which the development is very variable. In certain parts of the Italian Alps, however, especially between Ivrea and Domo d'Ossola, they become predominant.

This upper division of the crystalline schists is characterized by a more or less pronounced green tint, due to the presence of chlorite or hornblende, which recalls the name *pietre verdi*, given to these and other schists by Gastaldi and several other Italian geologists.

Below the chloritic and hornblendic schists occurs a large series of mica-schists, with which are intercalated, in conformable bedding, cipolin-limestones (*calcaires cipolins*), granular dolomites, and pure saccharoidal limestones, alternating with mica-schists and evidently forming part of the same formation.

The mica-schists become charged with felspar and pass thus into gneiss, with which they alternate. Black and white micas are associated in these rocks. In proportion as the series is descended, orthoclase becomes more abundant, and the gneisses predominate with a foliation which decreases until they pass into granitoid gneiss, in which the foliation disappears, but the broader features of stratification remain visible. This is well shown in the section of the Simplon *massif*, where the gorges of the Diveria are hollowed out, to a depth of 700 metres, in the horizontal beds of the granitoid gneiss known as the gneiss of Antigorio.

[1] "Sur la Constitution et la Structure des Massifs de Schistes Cristallins des Alpes Occidentales," par M. le Professeur Ch. Lory. "Etudes sur les Schistes Cristallins." London, 1888. (Abstracted from the French by Dr. F. H. Hatch.)

Prof. Lory does not recognize in the *Monte-Rosa zone* any beds belonging to the Carboniferous; and he believes that the crystalline schists of this part of the Alps have been exposed during the whole of Palæozoic times, without having been disturbed from their primitive horizontal position. They have gradually subsided during the Triassic period. The lower stages of this formation are not much developed in this zone; but the upper stage, represented by the *schistes lustrés*, have acquired an enormous thickness.

These Triassic beds are characterized by a remarkably crystalline texture. The limestones and dolomites which form the middle stage are granular and saccharoidal, and inclose authigenic crystals of albite. The *schistes lustrés* are composed in great part of crystallized minerals (quartz, mica, tourmaline, garnets, &c.), which are also certainly authigenic. This crystalline condition is uniform and constant, and independent of all dislocations and contortions which the beds have subsequently undergone.

The crystalline character of the sedimentary formations may be of assistance in understanding the origin of the crystalline schists. The foliation is generally parallel to stratification, the latter being always very distinct. Characters so uniform cannot be explained by the phenomena of slaty cleavage and crystallization under the influence of local mechanical actions. It is rather a general, universal, and original crystallization of the primitive rocks, which took place anterior to the deposit of all sedimentary formations.

The most important element of Prof. Lory's *third zone* are anthracitic sandstones. These sandstones belong to the Upper Coal-measures (*houiller supérieur*). The boundary between them and the crystalline schists is usually marked by a fault. But sometimes, as at the bridge of St. André, near the railway station at Modane, the latter appear under the sandstones, and then the foliation of the crystalline schists is conformable with the bedding of the Carboniferous sandstones. At this and other localities there occur in the lower portions of these sandstones conglomerates formed of slightly rolled fragments of crystalline schists, identical with those which crop out in the neighbourhood. It is therefore evident that the foliation and crystallization of the crystalline schists must be earlier than the Carboniferous period. Conglomerates, composed of fragments of the most diversified rocks from the crystalline schists, occur in the Upper Trias, in the Lias (*Col du Golet*), and in the Nummulitic Eocene (*massif des Encombres*). Each of these conglomerates contains fragments of all the preceding formations. Since these rolled pebbles have the characteristic structure, crystalline or foliated, of the rocks they are derived from, and since the foliation of the pebbles has no uniform direction in the conglomerates, it follows that the foliated or crystalline texture of the rocks of these various formations is, each for each, of earlier origin than the deposition of that which overlies it, and absolutely independent of the powerful mechanical actions which only fashioned these formations into mountains subsequently to the Eocene period.

Again, all the formations, from the Trias to the Eocene, contain microscopic crystals of silicates (felspars, mica, quartz, tourmaline), which are of contemporaneous origin with the rocks containing them, and do not, therefore, owe their existence to any of the dynamic processes which have subsequently acted upon this part of the Alps.

Since these silicates, which are identical with, or very analogous to, those of the crystalline schists, were formed in the Secondary and Tertiary deposits independently of all eruptive actions or special emanations, and anteriorly to all dynamic processes, it is unnecessary for the explanation of the origin of the primitive crystalline schists to assume physical conditions absolutely different from those of the Secondary or Tertiary periods.

In the remote epoch in which these schists were formed there were no terrestrial features, and consequently no detrital formations. The existence of organisms in a universal ocean, warmer and more heavily charged with saline matters than actual seas, was not yet possible; and there resulted combinations of crystallized minerals, the formation of which in later times became more local and restricted. But even as late as Tertiary times we still find traces of analogous reactions in the deposits of those remarkable *fiords* of the Eocene period which extend over a part of the actual site of our Alpine chains.

(2) Prof. Lory's *first Alpine zone*, or *Mont-Blanc zone*, comprises, in Switzerland, the *massifs* of the Bernese Alps and of St. Gothard; in Savoy, those of the Aiguilles Rouges and of Mont-Blanc; the chain of Belledonne; the small *massif* of Rocheray, near St.-Jean-de-Maurienne; the *massif* of Rousses, in Oisans; the *massif* of Pelvoux, between Drac and Durance; finally, the *massif* of the Maritimes Alps, between the Col de l'Argentière and the Col de Tende.

The characteristic feature common to all these *massifs* consists in the crystalline schists composing them being nearly always highly inclined or almost vertical. They do not appear to present the regular structure—the great anticlinal folds of the *Monte-Rosa zone*. This indicates that the *Mont-Blanc zone* is really the ancient part of the orogenic system of the Alps, and that its structure has resulted from the dislocations of different epochs.

Anthracitic sandstones occur also in this zone, but they are less developed and less continuous than in the *third zone*, and, as indicated by their plant remains, are of more recent date, being intermediate between the Coal-measures of Rive-de-Gier and those of Saint-Etienne.

On the western slope of this zone traces of dislocations, anterior to the deposition of these Carboniferous sandstones, can be recognized. They are indicated by clear unconformities at various points in the Mure basin and other places. But on the eastern slope of the same zone the Carboniferous sandstones and the crystalline schists are generally conformable.

These Carboniferous sandstones of the *first zone*, like those of the *third*, are accompanied by conglomerates containing numerous fragments of foliated crystalline schists, of which the petrographical characters are identical with those of the underlying crystalline rocks. These conglomerates are well known on both western and eastern slopes (*poudingues* of Valorsine, Grandes-Rousses, &c.) Since the Carboniferous sandstone on the eastern slope is conformable with the crystalline schists, the existence of large fragments of the schists in these conglomerates, clearly demonstrates that their foliation is anterior to all dislocations which have affected the *massif*. It was after the deposition of the anthracitic sandstone, between the Carboniferous and Triassic periods, that the principal dislocations took place, which have upheaved and contorted the crystalline schists and the anthracitic sandstones of the *first zone*. Wherever the Triassic beds appear nearly horizontal they rest, in conformable stratification, on the upturned edges of the older formations, whether anthracitic sandstones or crystalline schists.

The horizontal position of numerous shreds of Secondary rocks to be found at very variable heights indicates the character of the dislocations which have taken place at more recent periods in this part of the Alps. The ancient formations, already upheaved and contorted before the deposition of the Trias, have behaved like rigid masses, and have not lent themselves to the newer folding. They have been traversed by faults; and displacements have taken place along the planes of fracture, while at the same time following the divisional planes of stratification. The Secondary rocks, on the other hand, have behaved like flexible, and even, when argillaceous, like plastic bodies. They have only been completely fractured by the more important major faults; everywhere they have moulded themselves by multiplex folding to the new forms of their dislocated base. This flexible covering has slipped into the depressions formed by the subsidence, due to dislocation, of certain parts of its base. In this way the Secondary rocks present themselves on the flanks of the Alpine valleys in beds which are inclined and contorted in repeated folds, contrasting thus with the uniform curvature of the ancient rocks.

The powerful mechanical actions resulting from these dislocations of the *first Alpine zone* have often superinduced, in the argillaceous limestones of the Lias, phenomena of "stretching," lamination, and, above all, a slaty cleavage in a direction different from that of stratification. As to the crystalline schists, of which the plication took place at the end of the Carboniferous and before the Triassic period, the more recent dislocations have destroyed the regularity of their anticlinal and synclinal folds. Along the axes of the anticlinal ruptures, or following the bands of mica-schists—that part of the crystalline schists which offers least resistance—occurred the subsidences which have given rise to the actual Alpine valleys; it is following these directions, and *nearly always following the old synclinal folds*, that the ancient rocks have been cut up into *massifs*, separated by the bands of depression, where the Secondary rocks, adapting themselves to the new forms assumed by their base, have descended while undergoing plication; and their beds, highly inclined and often curiously folded, clothe the lateral walls of these depressions. The valley of Chamonix and l'Allée Blanche, the Combe d'Olle, the lower valley of the same stream, at Allemont, and that of Bourg-d'Oisans, are examples of this type of longitudinal Alpine valleys of the *Mont-Blanc zone*.

The *massifs* of crystalline schists represented in this zone are large remnants which have remained standing in ruins, the other parts of the primitive rocks having subsided either *en masse*, following great faults, or in detail, by a series of small slides, following the numerous joints, or the divisional planes of bedding. *Not one of them represents a regular and complete anticlinal fold.*

The various types of crystalline schist comprised in the Mont-Blanc zone succeeded one another in the same order as in the *Monte-Rosa zone.* They are also divided into two groups: the upper group—sericitic, chloritic, and hornblendic schists; and the lower group—mica-schists and true gneisses.

In the lower group there is a tendency towards the granitoid structure, and the rocks appear more or less massive, but yet in the main stratiform. They become rich in white mica, and assume a granulitic texture. These phenomena are developed along the anticlinal axes.

The crystalline schists of the upper group have a tendency to become richer in felspar the nearer one approaches the intra-Alpine limit of the zone. It seems that this corresponds with the direction in which alkaline emissions, accompanying the formation of these rocks, took place, the same direction afterwards becoming that of the great limiting fault of the zone. The schists pass thus into chloritic gneisses similar to those occurring near the station at Modane (*third zone*), or to the gneiss of Arolla (*fourth zone*); sometimes also into granitoid gneisses, both chloritic and hornblendic, as, for instance, at Cevins, in Tarantaise.

The tenacity of the chloritic and hornblendic schists, which is generally much superior to that of the mica-schists and true gneisses, and their tendency to develop felspar, which gives them greater consistency, explain the important *rôle* played by these rocks in the constitution of the culminating ridges and steeper *massifs* of the *first zone*. In the Mont-Blanc *massif* and in the eastern portion of the Pelvoux *massif* these "needles" and abruptly culminating ridges characterize the type of rock known as *protogine*. This name, the etymological sense of which must be forgotten, has been created to designate the type of rocks which predominates in the principal ridge of Mont-Blanc. The special character of these rocks consists in the mica being penetrated and partly replaced by chlorite. The granitoid protogine always contains two felspars—orthoclase and oligoclase, part of the orthoclase being usually replaced by microcline.

Prof. Lory thinks the protogine belongs to the upper group—that of the chloritic schists. In that case Mont-Blanc cannot be regarded as a central arch of elevation, and its "fan-structure" becomes simply a very sharp synclinal fold of the crystalline schists of the upper group, isolated by two faults, along which they have subsided, while acquiring a U-shaped fold.

In the Pelvoux-*massif* the protogine is even more largely developed than at Mont-Blanc. Here also it is stratiform, and alternates with chloritic gneisses like those of the western parts of the *massif*. A series of anticlinal and synclinal folds can be made out. The anticlines correspond to the Vallon des Étages, the Barre des Escrins (west slope), and the Combe d'Alefroide; and the synclines to the Combe de la Pilatte, the eastern slope of the Escrins (Glacier Noir), and the summits of Mont-Pelvoux.

From observations made near Bourg-d'Oisans, the author arrives at the conclusion that the *protogine* has originated by a modification of the chloritic schists. During their formation, a considerable increase in their felspathic constituent was produced by granulitic emissions which took place through the gneiss and mica-schists.

Like other important features in the structure of the Eastern Alps this replacement of chloritic schists by protogine follows the intra-Alpine limit of the *Mont-Blanc zone*, which limit is marked by the great fault-line which can be traced over 60 *lieues*, from Vallonise to Airolo. This must have been the direction in which took place those granulitic emissions, which, without giving birth to true eruptive masses, have modified the character of the old gneiss and mica-schists and developed in the chloritic and hornblendic schists the felspathic character which distinguishes the granitoid rock known as protogine.

THE ELECTRIC TRANSMISSION OF POWER.[1]

WHAT is power, and why should we wish to transmit it? Power has one very definite meaning in science, and several rather vague meanings in practice. We speak of a powerful athlete, the power of the law; we sing of the power of love; we say knowledge is power, and so on, using the word in several different senses. Now, in spite of the fact that a general audience feels a little anxious as to what troubles may be in store for it when a lecturer begins by being painfully exact, my telling you that by power an engineer understands the rate of doing work will not, I hope, make you fear that my remarks will bristle with technicalities.

When you walk upstairs you exert power—only, perhaps, the one-twentieth of a horse when you go up slowly, talking to other people. But when you run upstairs because you have forgotten something that you intended to bring down, then your exertions represent, perhaps, the one-tenth of a horse-power. You only get to the top of the stairs in either case, but the breathless sensation of running fast upstairs tells you that the more quickly you go the harder you are working. A person exercises power in the engineer's sense when he exerts himself physically, and the greater the exertion the greater the power. The exercise of power by the ruling classes, however, is unfortunately not necessarily accompanied by any exertion, physical or mental.

Probably the most familiar example of exerting power at a distance—that is, of transmitting power—is pulling a handle and ringing a bell in another room. I pull the handle, exerting myself slightly, and as the result the bell at the other end of the platform rings. Were not this such a very familiar operation I would call it experiment No. 1. You have doubtless all of you performed this experiment several times to-day, and—what is all important with an experiment—performed it successfully.

And yet it was not until just one hundred years ago that it dawned on people that if one person, A, wanted to attract the attention of another person, B, the place where the bell ought to sound was where B was, and not where A was. Indeed, in many English villages down to the present day the knocker principle of attracting attention is alone resorted to, with the result which you may remember happened when Mr. Pickwick was staying in Bath at lodgings in the Royal Crescent, and Mr. Dowler undertook to sit up for Mrs. Dowler, but "made up his mind that he would throw himself on the bed in the back room and *think*—not sleep, of course. . . . Just as the clock struck three there was blown into the crescent a sedan-chair with Mrs. Dowler inside, borne by one short fat chairman and one long thin one. . . . They gave a good round double knock at the street door. . . . 'Knock again, if you please,' said Mrs. Dowler, from the chair. 'Knock two or three times, if you please.' The short man stood on the step and gave four or five most startling double knocks of eight or ten knocks a-piece, while the long man went into the road and looked up at the windows for a light. Nobody came—it was as silent and as dark as ever." But the tall thin man, you may remember, "kept on perpetually knocking double knocks of two loud knocks each, like an insane postman," till Mr. Winkle, waking up from a dream "that he was at a club where the chairman was obliged to hammer the table a good deal to preserve order," met with the catastrophe which the readers of "Pickwick" will remember.

This episode shows what comes of having plenty of power and no means of transmitting it.

But if some houses can still dispense with mechanical or other methods of transmitting power, even to ring bells, factories cannot. The looms, the lathes, or whatever the machinery used in the factory may be, must either be worked by hand or foot in the old style, or it must be connected with the steam-, gas-, or water-engine in the new. On entering a large factory you see lines of rapidly-rotating shafting, and a net-work of rapidly-revolving belting, all employed in transmitting power. As a contrast to this, I now throw on the screen a photograph of Sir David Salomon's workshop at Tunbridge Wells, in which every machine is worked by a separate electric motor, thus saving to a great extent the loss of power that usually accompanies the mechanical transmission.

In America there are 6000 electromotors working machinery; in Great Britain hardly 100.

But it is not only in transmitting the power from the steam-, gas-, or water-engine of a factory to the various machines working in it, that electricity can be utilized. An incredible amount of power is daily running to waste in this and other countries because many of the rapid streams of water are too far away from towns for their power to have been hitherto utilized.

The holiday tourist, when admiring the splashing water dashing over the stones, hardly realizes that the money loss is as if the foam were composed of flakes of silver.

[1] Lecture delivered by Prof. Ayrton, F.R.S., at the Drill Hall, Bath, on Friday, September 7, 1888.

If we take as a low estimate that a large well-made steam-engine burns only 2 pounds of coal per horse-power per hour, the coal consumption which would be equivalent to the waste of power at Niagara would exceed 150,000,000 tons per annum, which at only 5*s.* or 6*s.* per ton means some £40,000,000 sterling wasted. And descending from big things to small, the River Avon, flowing through Bath, which, so far from being a roaring cataract, especially in dry weather, pursues its course with only a respectable orderly swish, still represents a certain amount of lost power. It has been estimated that from 25 to 130 horse-power runs to waste at the Bathwick Weir behind the Guildhall, depending on the season. If we take as an all-round average that the fall of this weir represents 50 horse-power, and that a steam-engine producing this power burns 150 pounds of coal per hour, it follows that with steam coal at 16*s.* per ton—the price at Bath—the waste at Bathwick Weir represents an income of £450 per annum, not a princely fortune, it is true, but too large to be utterly thrown away as at present.

This state of things will I hope, however, be shortly remedied, for, as you will see from the large map on the wall, it is proposed to put up eighty-one electric arc lamps throughout the streets of Bath, and to supply the 50 horse-power required for these lamps by the fall of the Bathwick Weir, supplementing the fall with a steam-engine at dry seasons.

The next large diagram shows the use that Lord Salisbury has made of the River Lea to electrically light Hatfield House, and to supply electric motive power to the various machines working on his estate. The following diagram shows the course of the Portrush electric railway, six and a half miles long, which is worked by the Bushmill Falls, situated at about one mile from the nearest point of the railway. And lastly, this working model on the table, kindly lent me by Dr. E. Hopkinson, as well as the diagram on the wall, represent the Bessbrook and Newry electric tramway, a little over three miles in length, which is also worked entirely by water power, the turbine and dynamo which convert the water power into electric power being at about three-quarters of a mile from the Bessbrook terminus. [Model electric railway shown in action.]

The newspapers of last week contained a long account of the spiral electric mountain railway that has just been opened to carry people up the Burgenstock, near Lucerne, and worked by the River Aar, three miles away, so that we see electric traction worked by distant water power is extending. But, splendid as are these most successful uses of water power to actuate distant electromotors, it is but a stray stream here and there that has yet been utilized, and countless wealth is still being squandered in all the torrents all over the world.

The familiarity of the fact makes it none the less striking, that, while we obtain in a laborious way from the depths of the earth the power we employ, we let run to waste every hour of our lives many many times as much as we use.

It is also a well-established, time-honoured fact that large steam-engines can be worked much more economically than small ones, and that therefore if it were possible to *economically* transmit the power from a few very large steam-engines to a great number of small workshops there would be a great saving of power, as well as a great saving of time from the workmen in these many small workshops having only to employ this power for various industrial purposes, instead of having to stoke, clean, repair, and generally attend to a great number of small, uneconomical steam-engines.

When delivering the lecture which I had the honour to give at the meeting of the British Association at Sheffield nine years ago, I entered fully into Prof. Perry's and my own views on this subject, and therefore I will not enlarge on them now. You can all realize the difference between the luxury of merely getting into a train instead of having to engage post-horses; of being able to send a telegram instead of employing a special messenger; or being able to turn on a gas tap and apply a match when you want a light, instead of having to purchase oil and a wick, and trim a lamp. Well, a general supply of power to workshops is to the manufacturer what a general supply of light or a general supply of post-office facilities is to the householder: it is all part of the steady advance of civilization that leads the man of to-day to go to the tailor, the shoemaker, the baker, the butcher, instead of manufacturing his own mocassins and lassoing a buffalo for dinner. And in case any of you may be inclined to think that we have gone far enough in these new-fangled notions, and we are all perhaps prone to fall into this mistake as we grow older, let me remind you that while each age regards with justifiable pride the superiority of its ways to those of its ancestors, that very age will appear but semi-civilized to its great-grandchildren. Let us accept as an undoubted fact that a general distribution of power would enable the wants of civilized life to be better satisfied, and therefore would greatly benefit industry.

There are four methods of transmitting power to a distance: (1) by a moving rope; (2) by air compressed or rarefied at one end of a pipe operating an air motor at the other end; (3) by water forced through a pipe working a water motor; (4) by electricity.

We have an example of the transmission of power through a short distance by an endless belt or rope in the machine geared together by belts on this platform, and in the rotatory hair-brushes at Mr. Hatt's establishment in the Corridor, Bath. At Schaffhausen, and elsewhere in Switzerland, the principle is employed on a large scale. Spain and other countries use it in connection with their mining operations; and lastly, wire ropes replace horses on many hilly tramways. Do not look, however, for the wire rope of the Bath cable tramways, for cable is only to be found painted on the sides of the cars.

For short distances of a mile or so there is no system of transmitting power in a *straight line* along the open country so cheap to erect, and so economical of power as a *rapidly*-moving endless rope; but the other systems give much greater facilities for distributing the power along the line of route, are much less noisy, and far surpass wire rope transmission in economy when the rope must move somewhat slowly, as in tramway traction, or when the distance is considerable over which the power is transmitted, or when the line of route has many bends.

In the same sense that an ordinary house-bell may be considered as a crude example of the transmission of power by a moving rope, the pneumatic bell at the other end of the hall which I now ring by sending a puff of air through the tube is a crude example of the transmission of power by compressed air. [Pneumatic bell rung.] Compressed air is employed to work from a distance the boring-machines used in tunnelling. The continuous vacuum-brakes used on many of the railways are also probably familiar to you, and the pneumatic system of transmitting power to workshops is shortly to be tried on a fairly large scale at Birmingham.

But distribution of power by water pressure is the plan that has hitherto found most favour in this country. That little water motor at the other end of the platform rapidly revolves when I work this garden syringe, and serves as a puny illustration of the transmission of water pressure. [Experiment shown.] Pressure water has been employed for years on a large scale at Hull for distributing power; also by Mr. Tweddle, as a means of communicating a very large amount of power through a flexible tube to tools that have to be moved about; but the grandest illustration of this principle is the vast system of high-pressure mains that have been laid throughout London, as you will see from the photograph that I now project on the screen of the map kindly lent me by Mr. Ellington.

The economy of this system is so marked and the success that has attended its use is so great that, did I not feel sure that electricity offers a grander system still, it would be with fear and trembling that I should approach the subject of this evening, the "Electric Transmission of Power." *Punch* drew six years ago the giant Steam and the giant Coal looking aghast at the suckling babe Electricity in its cradle. That baby is a strong boy now; let the giant Water look to its laurels ere that boy becomes a man. For the electric transmission of power even now bids fair to surpass all other methods in (1) economy in consumption of fuel; (2) more perfect control over each individual machine, for see how easily I can start this electric motor, and how easily I can vary its speed [experiment shown]; (3) ability to bring the tool to the work instead of the work to the tool—this rapidly-rotating polishing-brush, with its thin flexible wires conveying the power, I can handle as easily as if it were a simple nail-brush; (4) in greater cleanliness, no small benefit in this dirty, smoky age; (5) and lastly, there is still one more advantage possessed by this electric method of transmitting power that no other method can lay claim to—the power which during the day-time may be mainly used for driving machinery can, in the easiest possible way, be used during the night for giving light. I turn this handle one way, and the electric current coming by one of these wires and returning by the other works this electromotor; now I turn the handle the other way, and the current which comes and returns by the same wires as before keeps this electric lamp glowing. [Experiment shown.]

It might be said that the transmission of power by coal-gas, which I have excluded from my list, fulfils this condition, but so also does the transmission of power by a loaded coal-waggon. In both these cases, however, it is fuel itself that is transmitted, and not the power obtained by burning the fuel at a distant place.

Let us study this electric transmission a little in detail. I pull this handle, and the bell at the other end of the room rings; but in this case there is no visible motion of anything between the handle and the bell. [Electric bell rung by an electric current produced by pulling the handle of a very small magneto-electric machine.] Whether I ring the bell by pulling a wire, or by sending an air puff, or by generating an electric current by the exertion of my hand, the work necessary for ringing the bell is done by my hand exactly as if I took up a hand-bell and rang it. In each of the three cases I put in the power at one end of the arrangement, and it produces its effect at the other. In the electric transmission how does this power travel? Well, we do not know. It may go through the wires, or through the space outside them. But although we are really quite in the dark as to the mechanism by means of which the electric power is transmitted, one thing we do know from experience, and that is this: given any arrangement of familiar electrical combinations, then we can foretell the result.

Our knowledge of electrical action in this respect resembles our knowledge of gravitation action. The only thing quite certain about the reason why a body falls to the ground is that we do not know it; and yet astronomical phenomena can be predicted with marvellous accuracy. I mention the analogy, since some people fancy because the answer to that oft-repeated question, "What is electricity?" not only cannot be given exactly, but can only be guessed at in the haziest way, even by the most able, that therefore all electric action is haphazard. As well might the determinations of a ship's latitude at sea be regarded as a mere game of chance because we have not even a mental picture of the ropes that pull the earth and sun together.

This power of producing an action at a distance of many yards, or it may be many miles, by the aid of electricity without the visible motion of any substance in the intervening space is by no means new. It is the essence of the electric telegraph; and electric transmission of power was employed by Gauss and Weber when they sent the first electric message. I am transmitting power electrically whether I now work this small model needle telegraph instrument, or whether I turn this handle and set in motion that little electric fan. [Experiment shown.]

But until about ten years ago the facility that electricity gave for producing signals almost instantaneously at a great distance was the main thing thought of. The electric power consumed for sending the telegraph messages was so small, the amount of power lost *en route* comparatively so valueless, that the telegraph engineer had no need to trouble himself with those considerations that govern us to-day when we are transmitting power large enough to work a factory or an electric tramway. Although there are as many as 22,560 galvanic cells at the Central Telegraph Office, London, which cost some thousands annually to keep in order, what is that compared with the salaries of all the 3089 superintendents, assistants, telegraph-clerks, messengers, and the maintenance of the 1150 telegraph lines that start from the Central Office?

In all the last three systems in my list some form of power, such as flowing water, or the potential energy stored up in coal, wood, zinc, or other fuel, has initially to be utilized. This power is given to some form of air, water, or electric pump, which transfers the air power to the air, water, or electricity, by which it is conveyed to the other end of the system. There it is re-converted into useful mechanical power by means of an air, water, or electric motor.

You will observe that I class together air, water, and electricity; by that I do not mean to imply that electricity is a fluid, although in many respects it acts like a fluid—like a fluid of very little mass, however; or, odd as it may seem, like a fluid moving extremely slowly, for electricity goes round sharp corners with perfect ease, and without any of the phenomena of momentum possessed by rushing water. But what I particularly wish to impress on you by classing air, water, and electricity together is that electricity is not, as some people seem to think, a something that can be burnt or in some way used up and so work got out of it. Electricity is no more a source of power than a bell-wire is, electricity is a marvellously convenient agent for conveying a push or a pull to a great distance, but it is not by the using up of the electricity that electric lights burn or that electromotors revolve. It is by the electricity losing pressure, exactly as water loses head when turning the miller's wheel as it flows down hill, that work is done electrically.

This model shows, in a rough, symbolical way, what takes place in the transmission of power whether by air, water, or electricity. [Model shown.] The working stuff, whichever of the three it may be, is first raised in pressure and endowed with energy, symbolized by this ball being raised up in the model; it then gradually loses pressure as it proceeds along the tube or wire which conveys it to the other end of the system, the loss of pressure being accompanied by an increase of speed or by its giving up power to the tube or wire and heating it. This is shown in the model by the ball gradually falling in its course. At the other end there is a great drop of pressure corresponding with a great transference of power from the working stuff to the motor, and finally it comes back along the return pipe or wire, losing, as it returns, all that remains of the pressure given to it initially by the pump. The ball has, in fact, come back to its original level.

The problem of economically transmitting power by air, water, or electricity is the problem of causing one or other of these working stuffs—air, water, or electricity—to economically perform the cycle I have described.

In each of the four stages of the process—(1) transference of power to the working substance at the pump; (2) conveyance of power to the distant place; (3) transference of power from the working substance to the motor at the distant place; (4) bringing back the working substance—there is a loss of power, and the efficiency of the arrangement depends on the amount of these four losses. The losses may be shortly called (1) loss at the pump; (2 and 4) loss on the road; (3) loss at the motor.

Until 1870 the pump most generally employed for pumping up electricity and giving it pressure was the galvanic battery—scientifically an extremely efficient converter of the energy in fuel into electric energy, only unfortunately the only fuel a battery will burn is so expensive. A very perfect fire-place, in which there was very complete combustion, and very little loss of heat, but which had the misfortune that it would only burn the very best wax candles, would be analogous with a battery. The impossibility of using zinc as fuel to commercially work electromotors has been known for the last half-century, and the matter was very clearly put in an extremely interesting paper "On Electro-magnetism as a Motive Power," read in 1857 by Mr. Hunt before the Institution of Civil Engineers, a copy of which has been kindly lent me by Dr. Silvanus Thompson. Prof. William Thomson (Glasgow)—I quote from the discussion on the paper—put the matter very pithily by showing that, even if it were possible to construct a theoretically perfect electromotor, the best that could be hoped for, if it worked with a Daniell's battery, would be the production of a one horse-power by the combustion of 2 pounds of zinc per hour, whereas with a good actual steam-engine of even thirty years ago, one horse-power could be produced by the combustion of exactly the same weight of the much cheaper fuel coal. This argument against the commercial employment of zinc to produce electric currents is irresistible, unless—and this is a very important consideration, which is only beginning to receive the attention it deserves—unless, I say, the compound of zinc formed by the action of the battery can be reduced again to metallic zinc by a comparatively inexpensive process, and the zinc used over and over again in the battery. If the compound of zinc obtained from the battery be regarded as a waste product, then it would be much too expensive to work even theoretically perfect electromotors, if they were existent, by consuming zinc. Suppose, however, a process be devised by means of which burnt zinc can be unburnt with an expenditure comparable with the burning of the same weight of coal, then it might be that, although coal would still form the basis of our supply of energy, the consumption of zinc batteries might be an important intermediary in transforming the energy of coal, economically, into mechanical energy.

While, then, some experimenters are aiming at possibly increasing the working power of a ton of coal to eight times its present value by earnestly seeking for a method of converting the energy it contains directly into electric energy without the intervention of a wasteful heat engine, it should not be forgotten that in the cheap unburning of oxidized metal may lie another solution.

The solution of this latter problem is quite consistent with the principles of the conservation and dissipation of energy, since the heat required to theoretically unburn 1 pound of zinc is only one-seventh of that given out by the burning of 1 pound of coal. Further, it involves no commercial absurdity like that found in the calculations given in the prospectuses of many primary battery companies, which are based on zinc oxide, a material used in the manufacture of paint, maintaining its present price even if thousands of tons were produced. Unless all those who use primary batteries on this expectation intend to have the painters doing up their houses all the year round, they will find themselves possessed of the stock-in-trade of an oil and colourman on a scale only justified by a roaring business in paint.

Now about waste No. 3, the waste of power at the motor. That also is gone into fully in the discussion on Mr. Hunt's paper, and Mr. Robert Stephenson concluded that discussion by remarking "that there could be no doubt, from what had been said, that the application of voltaic electricity in what ever shape it might be developed was entirely out of the question commercially speaking. . . . The power exhibited by electro-magnets extended through so small a space as to be practically useless. A powerful electro-magnet might be compared for the sake of illustration to a steam-engine with an enormous piston, but with an exceedingly short stroke. Such an arrangement was well known to be very undesirable."

And this objection made with perfect justice against the electromotors of thirty years ago might also have been made to all the machines then existing for the mechanical production of electric currents. I have two coils of wire at the two sides of the platform joined together with two wires. I move this magnet backwards and forwards in front of this coil, and you observe the magnet suspended near the coil begins to swing in time with my hand. [Experiment shown.] Here you have in its most rudimentary form the conversion of mechanical power into electric power, and the re-conversion of electric power into mechanical power; but the apparatus at both ends has the defects pointed out by Mr. Hunt and all the speakers in the discussion on his paper—the effect diminishes very rapidly as the distance separating the coil from the moving magnet increases.

As long as electromotors as well as the machines for the production of electric currents had this defect, the electric transmission of power was like carrying coals to Newcastle in a leaky waggon. You would pay at least 16*s.* a ton for your coals in Bath, lose most of them on the way, and sell any small portion that had not tumbled out of the waggon for, say, 2*s.* a ton at Newcastle—a commercial speculation not to be recommended.

A very great improvement in electromotors was made by Pacinotti in 1860, but although his new form of electromotor was described in 1864 it attracted but little attention, probably because any form of electromotor, no matter how perfect, was commercially almost useless until some much more economical method of producing electric currents had been devised than the consumption of zinc and acids. Pacinotti's invention removed from motors that great defect that had been so fully emphasized by the various speakers at the reading of Mr. Hunt's paper in 1857. When describing his motor in the Nuovo Cimento in 1864, he pointed out that his principle was reversible, and that it might be used in a mechanical current generator. This idea was utilized by Gramme in 1870, who constructed the well-known Gramme dynamo for converting mechanical into electric power—a machine far more efficient than even Pacinotti had contemplated—and gave the whole subject of electrical engineering a vigorous forward impulse. Every subsequent maker of direct-current dynamos, or motors, has followed Gramme's example in utilizing the principle devised by Pacinotti, which was as follows. In all the early forms of dynamos or motors there were a number of magnets and a number of coils of wire, the magnets moving relatively to the coils, or the coils relatively to the magnets, as you see in this rather old specimen of alternate-current dynamo. To produce magnetism by a large number of little magnets is not economical, and Pacinotti's device consisted in arranging a number of coils round a ring in the way shown in the large wooden model [model shown], so that they could all be acted on by one large magnet. Instead of frittering away his magnetism, Pacinotti showed how it could be concentrated, and thus he led the way to dynamos and motors becoming commercial machines. Pacinotti's science, engineered by Gramme, not only made electric lighting commercially possible, but led to electricity being used as a valuable motive power. It was in their work that the electric transmission of power in its modern sense sprang into existence.

Quite recently an improvement in the same direction has been introduced into alternate-current dynamos by Mr. W. N. Mordey, for he has replaced the many magnets of the ordinary alternate-current dynamos with one large magnet, and so with his alternator weighing 41 hundredweight, which you see in this hall, he has succeeded in obtaining at a speed of 650 revolutions per minute an output of 53·6 horse-power with a high efficiency.

It may be convenient to mention at this stage the very valuable work that has been done by the Drs. Hopkinson, Mr. Crompton, Mr. Kapp, and others, in the improving of dynamos and motors by applying scientific principles in the construction of these machines. Were I lecturing on dynamos and motors instead of on the electric transmission of power, I would explain to you how, by putting more iron into the rotating armature, as it is called, and less wire on it, by shortening the stationary magnet, and generally by concentrating the magnetic action, these constructors have raised the commercial efficiency of these machines to actually as high as between 93 and 94 per cent.; further, how, by recognizing the force of the general principles laid down by Prof. Perry and myself, as to the difference that should exist in the construction of a motor and a dynamo, Messrs. Immisch have succeeded in constructing strong, durable electromotors weighing not more than 62 pounds per effective horse-power developed.

The subject is so entrancing to me, the results commercially so important, that I am strongly tempted to branch off, but the inexorable clock warns me that I must concentrate my remarks as they have concentrated the magnetic action.

87½ per cent. of the power put into an Edison-Hopkinson dynamo has actually been given out by the motor spindle when 50 horse-power was being transmitted. How does this compare with the *combined* efficiencies of an air-pump and an air-motor, or of a water-pump and a water-motor? I understand that in either of these cases 60 per cent. is considered a very satisfactory result. As far, then, as the terminal losses are concerned, electric transmission of power is certainly superior to air or water transmission.

(*To be continued.*)

SCIENTIFIC SERIALS.

THE Proceedings of the American Academy of Arts and Sciences for the year May 1887-88 contains many important papers. Among them we may mention one on the relative values of the atomic weights of hydrogen and oxygen, by Prof. J. P. Cooke and Mr. Richards, and a catalogue of all recorded meteorites, by Prof. Huntington. The volume also contains papers on the existence of oxygen, carbon, and certain other elements in the sun; the first two of these papers are chiefly remarkable for the absence of reference to the literature of the subjects, and it is charitable to suppose that this proceeds from the authors' ignorance.

Bulletin de l'Académie Royale de Belgique, June 30.—On the physical aspect of Mars during the opposition of 1888, by L. Niesten. An image of the planet taken by the author on May 5 shows that the so-called continent was again visible, which M. Perrotin had reported as having disappeared during the opposition of 1886. Analogous though less marked modifications in the form and colour of the spots seem to imply that these changes are periodical. The paper is illustrated by two successful photographs of the planetary disk, showing its appearance on April 29 and May 5, 1888.—Fresh researches on the optic origin of the spectral rays in connection with the undulatory theory of light, by C. Fievez. A new interpretation of the spectral rays is here offered by the author, who regards spectral phenomena as a particular case of optical interferences. According to this view luminous rays would produce at a given point of the spectrum a vibratory movement, whose intensity might be maximum or minimum according as one of the rays follows another by an even or uneven number of half wave-lengths. A spectrum presenting dark or bright rays would always proceed, not from a luminous source, but from at least two different sources. It would thus indicate the nature of the rays, whose undulatory movement was disturbed by the simultaneous action of the various luminous sources. M. Fievez concludes that Kirchhoff's absorption theory does not alone suffice to explain the observed facts, which may also be interpreted by means of the undulatory theory of light. His views are supported by a number of ingenious and skilfully executed experiments in spectral analysis.

Rendiconti del Reale Istituto Lombardo, July.—Contribution to the study of unilateral hallucinations, by Prof. A. Raggi. Reference is made to two cases of what may be called "one-sided" hallucination, in one of which the left ear, in the other the left eye, was affected, the corresponding organs on the opposite side remaining perfectly sound. The complex character of the phenomena described, as well as their distinctly psychological nature, left no doubt that these were cases of true hallucination, although a subordinate influence in their production might possibly be attributed to the state of the organs themselves. On the other hand, mention was made of a somewhat doubtful case of double hallucination as connected with the same order of mental phenomena.

Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg, tome xxxii., No. 2.—On the regularity of the structure of continents, by A. Karpinsky (in German).—On a journey to the Karaites of the western provinces of Russia, by W. Radloff (in German). Those of Troki in Lithuania, Lutsk, and Kovno, are speaking a Turkish dialect with a considerable admixture of Polish, Lithuanian, and White-Russian words.—Supplementary notes with regard to the catalogue of stars published by the Pulkova Observatory, by O. Backlund.—Researches into the energy of chemical combination, by N. Beketoff (in French), being a continuation of former researches, now extended to potassium and lithium oxides.—On the polarization-photometer and its application to technical purposes, by H. Wild.—On the influence of iodoform and iodine on the isobutylate of natrium, by A. Gorboff and A. Kessler.—Notes on the new edition of the "Mi'jâr i Jamâlî," published at Kazan in 1887, by C. Salemann, with a plate showing the kinship of various Persian dialects (all in German).

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 10.—M. Des Cloizeaux in the chair.—Remark on a point in the theory of secular irregularities, by M. F. Tisserand. The reference is to Le Verrier's statement regarding the stability of the planetary system, in connection with a certain position between Jupiter and the sun, determined at about double the distance of the earth from the sun. An attempt is made to ascertain whether there exists an analogous position, in which the originally slight eccentricity of the orbit of a small mass might gradually assume proportions calculated to disturb the general equilibrium of the system.—The French vines, by M. A. Chatin. The treatment is described, by which a vineyard at Meyzieux, Isère, has been preserved, like a green oasis, in the midst of the wilderness created round about by the combined attacks of Phylloxera, mildew, and black rot. The treatment consists partly in a systematic process of nippings (*éborgnements*), partly in the application of a strong manure, including granulated phosphorus and products, with a base of nitrogen, potassa, and lime.—Degrees of oxidation in the fluorescent compounds of chromium and manganese (continued), by M. Lecoq de Boisbaudran. Several experiments are described tending to show that the pink compound is the real cause of the fluorescence.—Observations of Barnard's new comet, made at the Paris Observatory (equatorial of the West Tower), by M. G. Bigourdan. This comet, discovered on September 2 at the Lick Observatory, showed on September 5 a round nebulosity from 1' to 1'·5 in diameter, with somewhat stellar nucleus of 11·5–12 magnitude, not occupying the centre of the nebulosity.—Positions of Brooks's comet (August 7, 1888), measured at the Observatory of Besançon, by M. Gruey. The observations are for August 9–12, when the magnitude varied from 7 to 9.—On the planet Mars, by M. Perrotin. These remarks are made in connection with four new designs of Mars, forming a sequel to those published in the *Comptes rendus* of July 16. They still show the two canals—one simple, one double—running from the equatorial region nearly along the meridian towards the North Pole. A new canal is also revealed which presents the appearance of a straight dark band traversing the white Polar ice-cap.—On the chlorides of indium, by MM. L. F. Nilson and Otto Pettersson. To the previously-determined trichloride, $InCl_3$ the authors here add three distinct and stable chlorides. These are a trichloride, $InCl_3$, a dichloride, $InCl_2$, and a monochloride, InCl, showing that a metal of the third group in the natural system of the elements may act as a mono-, a di-, and a tri-valent in clearly-defined combinations.—On the part played by symbiosis in certain luminous marine animals, by M. Raphaël Dubois. In previous communications the authors showed that the fundamental reaction necessary to produce animal luminosity was of the same order as those effected under the action of the ferments. Their further studies of *Bacillus pholas* and *Bacterium pelagia*, the respective parasites of *Pholas dactylus* and *Pelagia noctiluca*, enable them to reconcile their theory of photogenous fermentation with the hypothesis of the oxidation of a phosphorated substance, as proposed by some biologists. These researches also help to explain how marine phosphorescence may be caused by the disintegration of marine animals, and how this phenomenon may cease or reappear, and assume various degrees of intensity, according to circumstances.—On the myelocytes of the Invertebrates, by M. Joannes Chatin. Hitherto spoken of as present in the organism of the Vertebrates alone, the author here shows that the myelocyte formation occurs also in the Invertebrates. He makes it evident that they cannot be assimilated to *free nuclei*, but represent true cellules normally constructed, with all their essential parts. He further points out that the intimate structure and real nature of the myelocytes may be studied much more conveniently in the lower than in the higher organisms.—On *Heterodera schachtii*, by M. Willot. In connection with his recent communication (*Comptes rendus*, August 3), on the destruction of this micro-organism by sea-water, the author points out that Dr. Strubell, of the University of Erlangen, has independently, but subsequently, made the same discovery.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Chambers's Encyclopædia, vol. ii., new edition (Chambers).—British Dogs, No. 23: H. Dalziel (Upcott Gill).—The Constants of Nature, Part 1, A Table of Specific Gravity for Solids and Liquids: F. W. Clarke (Washington).—Index to the Literature of the Spectroscope: A. Tuckerman (Washington).—Biologia Centrali-Americana; Insecta—Coleoptera, vol. i. Part 2: D. Sharp.—The Electrical Engineer, vol. i.—Examples and Examination Papers in Elementary Physics: W. Gallatly (Geo. Bell).—Massage and Allied Methods of Treatment, 2nd edition: H. Tibbits (Churchill).—British Mosses, 2 vols., new edition: F. E. Tripp (Geo. Bell).—Memorial of Asa Gray (Cambridge, Mass.).—Index to the Literature of Columbium, 1801 to 1887: F. W. Traphagen (Washington).—Annals of Botany, August (Frowde).

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