THURSDAY, MAY 15, 1890.

THE ALTERNATE CURRENT TRANSFORMER.

The Alternate Current Transformer in Theory and Practice. By J. A. Fleming, M.A., D.Sc. Vol. I. "The Induction of Electric Currents." Pp. 479. (London: The *Electrician* Printing and Publishing Company, Limited, 1889.)

THE alternating current has of late years sprung into great commercial importance, and accordingly the laws regulating its flow, long known to a few, are becoming recognized and assimilated by the many. The behaviour of alternating currents is so vastly more complex than anything which had to be dealt with in the time-honoured chapter of the text-book concerning "divided circuits" for the case of steady currents, that a new literature has arisen, and a number of half-accepted new terms have been coined.

It is evidently with the aim of making accessible to average readers the greater portion of this subject that Dr. Fleming has put together the above-named book.

The volume is distinctly a compilation, a *réchauffée* of recent work, though it consists partly of a reprint of the author's own articles in the *Electrician*, and it is a compilation of a very useful kind. It brings together a quantity of floating information collected with a keen scent for practically useful items, as well as for topics of contemporary interest.

It is hardly a book to be recommended to the student as a logical treatise. The proof of the laws is a secondary consideration, and though proofs are indicated, it is more to link them on to other things than really to justify and deduce them. In fact the book has the air of being hastily written; but the facts are there, whether deduced rigorously or not, and the practical man, for whom it is written, will not be likely to find fault. In several instances, however, it can be claimed that the presentation of doctrines is as clear as could be wished and as the ability of the author would lead us to expect. Students will undoubtedly be glad of a book which contains so much useful information only accessible otherwise with difficulty.

The early part of the book, dealing with the modern treatment of magnetism, hysteresis, and the like, is fairly good, but is probably now superseded by some still more recent articles by Prof. Ewing himself. The next portion, on simply periodic currents, is very instructive. In it Lord Rayleigh's investigation of the laws of branching for alternating currents is incorporated, and the result applied to determine the correcting factor for a watt-meter; a clear explanation being given of why it is so difficult to measure the average power of an alternating current. Some of Mr. Blakesley's geometrical representations are also utilized; and the whole circumstances of a simply alternating current are very clearly explained.

Then comes an abstract of some of the too-long-buried researches of Prof. Henry, which the recent publication of his memoirs by the Smithsonian Institution has brought into prominence.

A brief account of the experimental investigations of Masson and Breguet, Blaserna, Helmholtz, on transient currents, of Hughes on the induction balance and on the throttling effect of iron wire, follows; together with the Maxwell-Rayleigh-Heaviside theory of the same.

We then come to the main subject of the book—the laws of mutual induction and the theory of induction coils or transformers. Here the author enters into very instructive detail, showing how to deal with transformers containing iron, and incorporating the researches of Hopkinson, Forbes, Sumpner, Ferraris, and Kapp, as well as the general theories of Maxwell and Lord Rayleigh.

A chapter headed "The Dynamical Theory of Current Induction" follows, wherein Prof. Garnett's summary of Maxwell's electro-magnetic ether models is reproduced; some instructive explanations of many Maxwellian ideas is given in a much clearer and more elementary form than is frequent; some experiments and articles of the present writer are incorporated; and lastly, Mr. Tunzelmann's abstract of Hertz's papers is reprinted once more. It is to be regretted that we have not the advantage of a fresh abstract and discussion of these papers by Dr. Fleming himself. So much in Hertz's papers was confessedly crude and tentative that it would have been much more satisfactory to have had a real digest from a contemporary point of view, instead of the useful but now out-of-date summary with which most persons were already familiar.

Perhaps also it may without offence be suggested that a free use of quotation marks in this last chapter, possibly in other chapters also, would not have been out of place. One is a little startled to find whole paragraphs and diagrams incorporated into a book without rather more explicit statement concerning their origin. I may instance pp. 380, 408, 409, among others, as having struck me personally with some surprise, though very likely the feeling was unjustifiable.

It may be useful if I record such trifling slips as I have noticed. Quite possibly some are not erroneous at all. On p. 7 the assertion is made that Faraday "came to see that that which he had denominated the *electrotonic state* is really the amount of electro-magnetic momentum which the circuit possesses." As a matter of history this is surely incorrect? And is there any evidence for the statement on p. 2, that Faraday's failure to obtain current induction in 1825 and 1828 was because his galvanometer circuit was not closed? It seems very improbable. At the bottom of p. 67 the argument seems to me incorrect and confusing. In the diagram on p. 140 *current* should appear as a factor in the lengths OB, BA, &c. On the top of p. 145, there is no need for L and N to be *both* zero in order that the watt-meter factor, F, may equal unity; it is sufficient if the time constant of the fine wire shunt alone vanishes. On p. 209 a p is twice dropped out of an equation. On p. 253 the statement is made "that we may regard the inductance of a conductor as an effect which is due to the fact that the current takes time to penetrate into the conductor"—a statement which is by no means true. And two pages on we read, "as the frequency of alternation is increased, the resultant self-induction of the circuit is lessened, but [? so that] although the true resistance is increased, the impedance may be diminished on the whole." It may, however, be more truly asserted that no increase in frequency can diminish impedance: it always tends to increase it; and in no case can the impedance of a conductor to alternating currents fall below that felt by steady ones. Both resistance and impedance increase with frequency. It is true that inductance diminishes, but the diminution is very slight except for iron rods. The punctuation of p. 353 has gone somewhat astray.

All these are trifles: the average level of the book is high, and it contains few dull pages. The practical importance and interest of the subject treated is so great that there should be little need to urge students and electrical engineers to make themselves acquainted with it, but I do urge them nevertheless; and they may think it fortunate that Dr. Fleming has managed to find time to issue so instructive and readable and well-timed a volume.

Oliver J. Lodge.

McKENDRICK'S "SPECIAL PHYSIOLOGY."

Special Physiology, including Nutrition, Innervation, and Reproduction. Vol. II. By J. G. McKendrick, M.D., LL.D., F.R.S. (Glasgow: Maclehose and Sons. London: Macmillan and Co. 1889.)

IN the first volume the only purely physiological part was that on muscle, leaving all the rest of the science to be treated of in this volume, which thus includes the physiology of digestion, nutrition, blood and circulation, respiration and the nervous system, as well as reproduction. It is evident that the book must either be of an entirely elementary character, or that the treatment must in parts be extremely inadequate, in order to include all these subjects within the dimensions of a moderate sized volume. As a matter of fact, it lies open to both these objections. In some places the author hampers himself in the treatment of the purely physiological part of the subject by expounding the first elements of chemistry and physics (for the benefit, I suppose, of the average Glasgow student); while other parts, though good, are much too condensed to be understood by the reader who is ignorant of the first principles of science. This disproportion in the treatment of the various subjects meets us at the very beginning of the volume, where twenty pages are devoted to dietetics before any description has been given of the processes of digestion.

In the section on digestion a very good condensed account is given of the theory of secretion. One is surprised, however, to meet with the statement that the submaxillary ganglion can act as a reflex centre. The importance of this view for the physiology of sporadic ganglia is enormous; yet Prof. McKendrick is content with describing Claude Bernard's old experiments, which seemed to support it, and makes no mention of the researches of Bidder and Schiff, made so long ago as 1867, which showed that the secretion obtained in Bernard's experiments was due to recurrent fibres of the chorda tympani, and not to any action of the ganglion as a reflex centre.

The account of the action of the bile on the chyme is not quite accurate. He says: "At the same time the taurocholate of soda throws down the non-peptonized albuminous matters, such as coagulable albumin and syntonin, while the hemialbumose and peptones remain in solution." As a matter of fact, the precipitate consists of parapeptone (syntonin) with a small quantity of peptones.

In describing the formed elements of the blood, no mention is made of the plasma or granule cells. Yet these are daily assuming a larger importance in pathological processes, and every student who is to study medicine should at any rate know of their existence.

In the section on coagulation as fair an account is given of Wooldridge's work on the subject as is possible in the limits of a page and a half; but in his summing up of the differences between this observer and Halliburton, he does not seem to have grasped Wooldridge's theory. He rejects this on the grounds that all Wooldridge's work was done with peptone plasma (which was not the case), and that fibrinogen (Hammarstens) contains no lecithin and can yet clot on addition of lecithin free ferment. That fibrinogen contains no lecithin is, to say the least, extremely doubtful. Bunge states that he has never succeeded in preparing any proteid free from phosphorus. It is practically impossible, however, to form a good judgment on the merits of Dr. Wooldridge's work without reading all his papers on the subject. In none of them has he discussed the question in all its details, and it is probably on this account that his work has been so misunderstood and misrepresented.

It is surprising how few books on physiology mention the *rôle* of the spleen (made so much of by Metschnikoff) as the great *blood-filter*, where all effete blood corpuscles and other deleterious materials are devoured and destroyed by the cells of the splenic pulp. In this volume the rhythmic movements of this organ are fully described, and a long list is given of the extractives that it contains, but its function is left entirely in doubt.

The next two sections, on the circulation and respiration, present the subject fairly completely, and are brief without being obscure. Yet these are not free from some misleading statements. Thus the depressor nerve is included among the afferent nerves that act on the inhibitory or accelerating cardiac centres, so that a student would imagine that stimulation of this nerve lowered the blood-pressure by reflex inhibition of the heart—a mistake one meets with only too often in teaching. Again, in describing the forces concerned in carrying on the circulation through the capillaries, he makes the following statement:—

> "Some have supposed that it is supplemented by an attractive influence exerted by the tissues (*vis a fronte*), and the statement is supported by the observation that, when there is an increased demand for blood owing to active nutritional changes, there is an increase in the amount of blood flowing to the part, such as occurs, for example, in the mammary gland during lactation, and in the growth of the stag's horn. Such an attractive influence on the part of the tissues is quite conceivable as a force assisting in the onward flow of blood, acting along with capillarity."

It is rather hard to see how an attractive influence on the part of the tissues can assist in the onward flow of blood, even when it *is* assisted by capillarity. At any rate this statement is sure to be devoured greedily by the studious fool, who will thereafter reproduce it on all possible occasions, probably as the chief factor in the circulation of the blood.

In discussing the nervous mechanism of respiration, the author confines himself almost entirely to an exposition of Marckwald's views. Apnœa is referred to a hyperoxygenation of the blood, no mention being made of the fact that it may be produced by positive ventilation with any inert gas, and so must be mainly a reflex effect.

Surely, too, in the treatment of the changes in the blood, the researches of Bohr, Blix, and others, on the combination of hæmoglobin with CO_2, were worthy of note.

In the section on the kidney, about 30 pages are devoted to an elaborate description of the normal and abnormal constituents of urine, with their tests and quantitative determination, while the subject of the process of secretion itself is dismissed in the ridiculously small space of three pages.

The final section, on the nervous system, is one of the best parts of the book. Especially good are the pages treating of the special senses. The chapters on the spinal cord and brain are less complete, and present several omissions and errors. Thus no mention is made of the perfectly definite antero-lateral ascending tract, and the knee-jerk is referred to as a true reflex, which is, to say the least, highly dubious. Again, the statement is made that clots in, or lesions of, the corpus striatum cause hemiplegia, whereas this is rarely or never the case unless the internal capsule is also implicated.

Throughout the work the author lies under the disadvantage of having tried to cater for two distinct classes of students, beginners and those who have already a fair general knowledge of the subject. For the former the work is too large and not sufficiently accurate; for the latter, in most parts, too meagre. Still it will be found useful by many of the latter class who have enough critical power to eschew the evil and choose the good, and will serve them as an excellent introduction to the reading of original memoirs. E. H. S.

OUR BOOK SHELF.

I. *Historia Naturalis Itinerum N. M. Przewalskii per Asiam Centralem.* Augustissimus auspiciis sumptibusque ab Societate Imperiali Geographica Rossica edita. Pars Botanica elaboravit C. J. Maximowicz. Volumen I. "Flora Tangutica." Fasciculus 1, Thalamifloræ et Disciflorae. 4to, pp. 110, cum tabulis 31.

II. Volumen II. "Enumeratio Plantarum hucusque in Mongolia nec non in adjacente parte Turkestaniæ Sinensis lectarum." Fasciculus 1, Thalamifloræ et Disciflorae. Pp. 138, cum tabulis 14.

III. *Plantæ Chinenses Potaninianæ nec non Piasezkianæ* (*Acta Horti Petropolitani*, Vol. XI., pp. 1–112). Elaboravit C. J. Maximowicz. (St. Petersburg Botanic Garden, 1889.)

Here are three separate contributions to the flora of Eastern Central Asia, by the well-known authority on the botany of Central and Eastern Asia. It is now nearly forty years since Mr. Maximowicz, through the force of circumstances, had an opportunity of exploring Mandshuria, the results of which he published under the title of "Primitiæ Floræ Amurensis." He was attached as botanist to the Russian frigate *Diana* on a scientific voyage round the world, but in consequence of war breaking out with England and France he was landed in Mandshuria, where he spent three or four years, returning through Siberia and European Russia to St. Petersburg. Subsequently he has visited Japan two or three times, and made large collections of dried plants, and his life, apart from official duties, has been devoted to working out the botany of temperate Asia.

It was known to botanists that he was engaged on the collections made by the renowned Russian explorer Przewalski and others, and we now have the first instalments in a connected form. Many of the novelties he had previously published in the *Mélanges Biologiques* and elsewhere. From the titles cited above, it will be seen that the plan of publication is, if not exactly an ambitious one, at least very laborious, involving much repetition. Possibly such conditions were imposed upon the author. Anyhow, it seems a great pity that the materials were not all worked up in one enumeration. This course would have been far preferable from a practical standpoint, and, what is of greater importance, there would have been a reasonable prospect of its being finished within a few years. With all Mr. Maximowicz's capacity for work, it seems unlikely that he can hope to reach the end on the present elaborate scale. The aggregate of the two quarto publications is 250 pages, and contains the Thalamifloræ and Disciflorae of the collections. At the outside, this is only a sixth of the flowering plants. Then there is the octavo enumeration of Chinese plants brought down to the same point, and this is not the whole of Mr. Maximowicz's botanical work in hand. Recently he issued a monograph of the genus Pedicularis, comprising about 250 species, nearly 100 of which were new, and these mostly Chinese. When it is added that Mr. Maximowicz is a very critical worker, some idea may be formed of the magnitude of the task he has undertaken.

Glancing over the pages we find that the novelties consist almost entirely of new species of old genera, chiefly of those of a wide range, in the northern hemisphere, at least. In fact, only two new genera are described: *Clematoclethra*, near *Actinidia* (which Maximowicz places in the Dilleniaceæ in preference to the Ternstrœmiaceæ), and *Tetraena*, an obscure plant provisionally referred to the Zygophyllaceæ. New genera are more numerous in Dr. Henry's collections from the warm temperate regions of Central and Western China.

W. Botting Hemsley.

Le Glacier de l'Aletsch et le Lac de Märjelen. By Prince Roland Bonaparte. (Paris: Printed for the Author, 1889.)

In this ample pamphlet the author gives an account of the well-known glacier of the Aletsch and the neighbouring mountain region, in the course of which it is incidentally mentioned that the glaciers are again showing signs of increase after a period of general retreat which began in 1854. This statement, I think, requires some qualification, for the Gorner glacier certainly was advancing about the year 1859. The most marked diminution occurred in the next decade, and it did not commence till, at any rate, after 1861. The author describes the curious Märjelen See, which has already been noticed in these pages (vol. xxxvi. p. 612), giving some statistics as to its area, depth, &c. He quotes also a list of the occasions, so far as known, since 1813, on which its waters have escaped beneath the Aletsch glacier. In this, however, there is either an omission or a misprint. It states that in 1859 *le lac se vide*. This may be true, though it seems improbable, for the lake was also drained in 1858. In the latter part of August in that year I saw it for the first time. It was then full. The next evening I again visited the lake. The water had almost all vanished, and the great blocks of ice were stranded on the muddy floor. In reference to this floor the author makes a statement which I fail to understand: "Le bassin du lac est une ancienne moraine de fond d'une des branches du glacier de l'Aletsch. Unless this mud be claimed as *moraine profonde*—and this I should dispute—the assertion seems to me without any valid foundation. The lake lies in the upper part of a small valley, worn by the passage of ice into a shape something like the pointed half of the bowl of a spoon. Another statement appears to me of questionable accuracy. The author notices the earth pillars on the southern slopes of the Eggishorn, describing them correctly, but saying of them, "Les pyramides des fées, aussi appelées 'blocs perchés.'" Surely this is an unwonted extension of the latter term.

The pamphlet, in short, is rather disappointing. It is beautifully printed on quarto pages with large margins, and is illustrated with three photogravures of glacier scenery, which would be improved by the omission of the human figures, for these by contrast look like negroes in mourning; but it tells us little that is new, and is a "popular" article rather than a scientific memoir.

T. G. BONNEY.

LETTERS TO THE EDITOR.

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Panmixia.

PRIVATE communications which I have received from naturalists interested in this controversy, and from Mr. Romanes himself, have thrown light on the apparently irreconcilable difference of the views which have been expressed.

I think it desirable that an explanation should be afforded to the readers of NATURE.

When Mr. Romanes contends that cessation of selection leads to a dwindling in the size of a useless organ, he now tells me that he assumes that the mean size of the part in all born (what we may call the birth-mean) was smaller than the mean size of that part in those individuals surviving under selection. Hence the withdrawal of selection substitutes in the adult survivors the lower birth-mean for the former higher selection-mean.

Mr. Romanes had not specifically stated that he made this assumption.

On the other hand, I had—for the purpose of estimating purely and solely the result of panmixia and cessation of selection—assumed that birth-mean and selection-mean were identical, in which case the withdrawal of selection would, of course, not alter the mean.

To assume that birth-mean is smaller than selection-mean in a given case seems to me to be introducing causes other than panmixia or cessation of selection.

It is evident that cases are *possible* in which the mean given by selection is identical with the birth-mean—others in which it is *smaller* than the birth-mean, and others in which it is *larger*. Special causes of a complex character determine whether the ratio is one or the other. If we are to consider the effects of cessation of selection alone, apart from other causes, it seems to me that we must not introduce causes which affect the ratio of birth-mean and selection-mean; we must eliminate them altogether by assuming the ratio to be one of equality. Hence my conclusion that panmixia or cessation of selection alone cannot produce the dwindling of an organ.

If, however, we admit the assumption that the selection-mean is larger than the birth-mean, Mr. Romanes has my full concurrence in stating that cessation of selection leads to dwindling, and I am of course aware that, given that assumption, Weismann and Galton are of the same mind.

The point of interest therefore shifts. The question is, whether we are justified in assuming that in organisms generally in a state of nature the mean size of an organ or part in the selected survivors is larger than in all born, or, to put it fully, larger than would have been the mean size of the part in all born supposing that they had all reached maturity.

I do not think that we have data which warrant this assumption. It is, I think, certain that some cases must sometimes occur in which this is the case, and others in which the selection-mean-size is *smaller* than the birth-mean-size. It is not improbable that in well-established species there is identity of the two means. This is, however, a question which ought to be settled by observation—*not* of domesticated races, but, if possible, of wild forms.

It seems to me that this assumption is precisely what Mr. Darwin considered, and refused to make, so that he avoided attributing dwindling of parts to the cessation of selection. He says ("Origin," 6th ed., p. 401): "If it could be proved that every part of the organization tends to vary in a greater degree towards diminution than augmentation of size, then we should be able to understand how an organ which has become useless would be rendered, independently of the effects of disuse, rudimentary, and would at last be wholly suppressed." Mr. Darwin says, "If it could be proved." This is really the whole point. If the greater size of selection-mean than of birth-mean could have been proved, Mr. Darwin was ready to formulate the doctrine of dwindling by cessation of selection. But, apparently, it could not be proved then. It has not been proved yet. I do not think it at all impossible that it may be proved. The facts are as yet not recorded.

E. RAY LANKESTER.

May 10.

Bertrand's Idiocyclophanous Spar-prism.

IT is a good thing that Prof. Silvanus Thompson has brought the above prism to the notice of the Physical Society (see NATURE, vol. xli. p. 574); it is certainly remarkable that M. E. Bertrand himself has never thought fit to publish any description of his interesting invention. Perhaps it may be worth while to mention a fairly simple method of constructing the prism (which may easily have occurred to others besides myself, and) which has the advantage of requiring only two artificially-worked surfaces, and hence of interfering as little as possible with the natural rhombohedral crystal of Iceland spar.

Four plane, polished faces are required for the prism, which is, in fact, a four-sided parallelopipedon, having two opposite sides parallel to the optic axis, while the two others make an angle of 45° with it.

Now, since in Iceland spar the faces of the natural rhombohedron make angles of very approximately 45° (strictly, 45° 24′) with the optic axis, two of these faces can be utilized for the last-mentioned pair of prism-sides.

Take, then, a cleavage-rhomb of spar, about 1 cm. in thickness, and having edges about 4 cm. in length (Fig. 1); observing

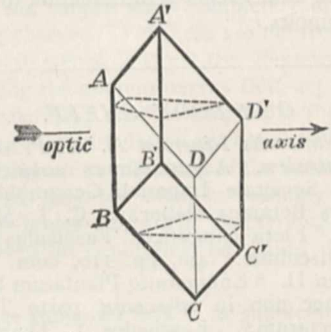

FIG. 1.

that both the face A B C D and the opposite one, A′ B′ C′ D′, are flat and free from blemishes (such a crystal is easily found, even in these spar-famine days). Grind away the solid angle A′ down to about the level shown by the dotted lines, working the face thus obtained so that it makes an angle of 45° with the natural face A B C D. Cut away the opposite solid angle C in a similar way, so as to make another plane, parallel to the first. Polish the two cut surfaces, and the prism is complete in all essential particulars.

Thus, if a beam of common white light is allowed to fall normally on one of the worked surfaces, A, Fig. 2 (which is a section of the prism), it will be (1) totally reflected at the natural face B (corresponding to A B C D in Fig. 1); (2) pass on through the crystal parallel to the optic axis; (3) undergo another total reflexion at the opposite natural face C; and (4) finally emerge through the second worked plane D. An eye placed close to D will then observe the well-known pair of ring-systems side by side, one set complementary to the other.

A very convenient source of illumination seems to be a lamp-flame within a globular opal shade, placed at such a distance that the three images of it produced by the action of the prism (the centre image formed, of course, by the superposition of two, similarly polarized) just touch each other. Two of these images are then filled (like a lantern-disk) with the complementary ring-systems; and by a very slight motion of the crystal the rings pass from a given disk to the adjacent one, becoming complementary in so doing. (It is hardly necessary to explain, for no doubt Prof. Thompson did so fully, that the whole prism is precisely

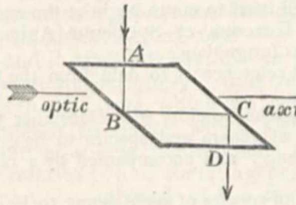

Fig. 2.

equivalent to a train of two double-image prisms with refracting angles of 45°, having between them a plate of spar with surfaces at right angles to the optic axis; a "Huyghens apparatus," in fact, with an interposed spar-plate instead of the usual selenite film.)

I may add that I have found it convenient, in order to demonstrate the principle of the prism, to divide it into halves; or, more strictly, to cut a piece of spar so as to form one half of the prism only, as shown in Fig. 3. Then, if common light from

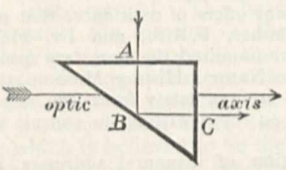

Fig. 3.

the lamp-shade (as described above) is allowed to enter the face A, and a tourmaline is held in the path of the rays emergent from C, ring-systems are seen just as when a double-image prism is used as a polarizer and a plate of spar held in front of it. Also, if plane-polarized light is allowed to enter C, and the eye is held close to A, ring-systems are seen side by side; that portion of the spar through which the rays pass after total reflection at B acting, of course, exactly as a double-image analyzer. In fact, the prism may, in this position, be used alone as a "Savart's polariscope" to detect traces of polarization in sky-light, &c. But for this application, the prism would possess, in the eyes of the true votary of science, the inestimable value of being of no practical utility whatever.

Queen's College, Oxford. H. G. Madan.

Coral Reefs, Fossil and Recent.

Dr. von Lendenfeld's account of the dolomites of the Italian Tyrol, in his letter on "Coral Reefs, Fossil and Recent," is a very valuable contribution to this interesting question; but I think he can hardly have fallen in with the new edition of Darwin's "Coral Reefs," or he would not have asserted that in the discussion "the structure of our Triassic limestone mountains has been left out of account." In the appendix (p. 332) I wrote:—"If those geologists are right who consider the Schlern dolomites as being to a great extent due to reef-building corals, we have, in the Triassic deposits of the Italian Tyrol, reefs thick enough to satisfy the most exacting requirements." I could not venture upon a more positive statement, because I knew controversy on this question was not ended, and I had not myself, though fairly familiar with the "Dolomites," discovered evidence which appeared to me conclusive (though I incline to the above opinion myself), and because I considered that the view advanced several years since by Richthofen required some modification—indeed, as to one detail, if I understand him rightly, I should differ from Dr. von Lendenfeld.

I am confirmed in my idea that he has not read this book, because I find that one of his chief arguments—that against the indefinite lateral extension of a coral reef on a talus of its own building—appears to correspond with one advanced by myself on p. 327, differing only in the addition of an arithmetical example; one of which, indeed, I did work out, but afterwards suppressed as needless, the truth of the statement being obvious when it was once pointed out. T. G. Bonney.

Bison and Aurochs.

In regard to Prof. Newton's letter in your issue of the 8th, I beg to state that in restricting the name aurochs to the European bison, I have merely followed the general custom of English zoologists.

Citing a few authorities, I may first make the following extract from a paper by Prof. W. B. Dawkins, published in the Quart. Journ. Geol. Soc., vol. xxii. p. 394 (1866). There, after alluding to the Indian gaur, this author writes, "the term *Aurochs* has been restricted to the European bison by the authority of Buffon, Cuvier, and Prof. Owen; the term *Urox* or *Bos urus*, to the species under consideration [the extinct wild ox of Europe] by Julius Cæsar, Pliny, . . . also by Cuvier, Nilsson, and our great naturalist, Prof. Owen."

Again, in the article on Ruminants by the late Prof. Garrod in "Cassell's Natural History" (2nd ed., p. 35), the term aurochs is applied to the European bison. Finally, we find in Prof. Flower's "Catalogue of Mammalia in the Museum of the College of Surgeons," p. 232 (1884), the animal in question mentioned as the *European Bison* or *Aurochs*.

I find, however, that modern German zoologists (see Brehm's "Thierleben," vol. iii. p. 386) consider it proved that the name *Aurochs* belongs properly to the extinct *Bos primigenius*; and they term the bison, as Prof. Newton states, the *Wisunt*. If this be really correct, English zoologists must accept the emendation. R. Lydekker.

The Lodge, Harpenden, Herts.

The Haunts of the Gorilla.

Concerning Mr. Du Chaillu's saying (see Nature, May 1, p. 19) "that, so far as he is aware, no white man has been able since his time to penetrate to the haunts of the gorilla and bring home specimens killed by himself," I beg to remark that Herr von Koppenfels, in the years 1873–80, killed personally a number of gorillas in the environs of the Ogowé, and sent 3 large specimens, with their skeletons, to the Dresden Museum, some of which I described in the *Mittheilungen aus dem königl. zoologischen Museum zu Dresden*, vol. ii. 1877, p. 230 *seq*. The Museum in Stuttgart also contains several specimens killed by that intrepid traveller; and other museums, I believe—American museums, for instance—possess some. (See also his remarks in the *American Naturalist*, vol. xv. p. 447; and *Die Gartenlaube*, 1877, p. 416 *seq*., with plate; as well as mine in *Der zoologische Garten*, 1881, vol. xxii. p. 231.) Herr von Koppenfels, who died in the year 1884 in Erfurt, in consequence of diseases acquired in the tropical climate, says (*l.c.*) that the haunts of the gorilla in West Africa are in the forests between the mouths of the Mimi and the Congo Rivers, *i.e.* between 1° N. lat. and 6° S. lat. How far the region extends into the interior is even yet unknown. A. B. Meyer.

Royal Zoological Museum, Dresden, May 7.

Flat-fishes.

Mr. Gulick, in Nature, vol. xli. p. 537, has raised a puzzling point about the flat-fish. In the case of his two Japanese species, it might appear that the ancestor of them both varied in the two directions as to the position of its eyes, &c., and that by the segregation of each form, *neither of which had any advantage over the other*, two species eventually were evolved. But this is not so clear in other cases, apparently. On the American coast of the Pacific, there is a flat-fish, *Paralichthys californicus*, Ayres, which is said by Messrs. Jordan and Goss to be almost as frequently dextral as sinistral. Here, then, is the same sort of variation exactly, yet we see no evidence of segregation and the formation of new species. In the whole subfamily *Soleinæ*, the eyes and colour are on the right side: now, if the "dextral" soles segregated themselves, having no advantage in being dextral rather than sinistral, what has become of all the sinistral ones? If there was no natural selection at play, ought we not to get some sinistral species of *Solea?* Perhaps it may be said that *Solea*, as such, never varied in this way, and was always dextral. But this cannot be so, since we have it on Day's authority that the common sole has a reversed aberration. But, after all, the allied *Cynoglossinæ* are sinistral soles.

Taking the *Pleuronectidæ* as a whole, we certainly get a division into dextral and sinistral groups, which might be supposed to be the result of a "like to like" segregation at an early period. The following table of the sub-families, compiled from Messrs. Jordan and Goss's excellent work on these fishes, illustrates the point :—

(1) *Hippoglossinæ :* normally dextral, except the tropical species, which are sinistral.

(2) *Pleuronectinæ :* sinistral flounders.

(3) *Oncopterinæ :* dextral.

(4) *Platessinæ :* dextral, but *Platichthys stellatus* is frequently sinistral.

(5) *Soleinæ :* dextral soles.

(6) *Cynoglossinæ :* sinistral soles.

But how comes it that the tropical flounders are nearly all sinistral, while the Arctic and Antarctic ones are chiefly dextral?

It would be interesting to know more of the reversed aberrations which occur. *Platessa flesus* var. *passer* (Linn.) is a reversed form, and Day records reversed aberrations of *Solea solea*, *Pleuronectes rhombus*, and *P. maximus*, while others have been noted by various writers. T. D. A. Cockerell.

West Cliff, Custer Co., Colorado, April 25.

Variation in the Nesting-Habits of Birds.

In connection with T. D. A. Cockerell's letter, *re* the nesting-habits of the blackbird in Colorado, it may be of interest to note that in the grounds around our residence about a fortnight ago, I discovered the nest of a blackbird (*Merula vulgaris*) built upon the ground close to a boundary wall about five feet high. The bottom of the nest is resting on the ground, but there is some trailing ivy growing around—but not on the wall—which supports it at sides and partially obscures it. There is a public road on the other side of the wall and the noise of considerable traffic. There are many suitable trees, bushes, and shrubs, all around, some of which have been utilized by other blackbirds—indeed, there is a tree within a few feet of the nest, which would have been suitable but for the chances of observation from the road. Thos. Swan.

Bankplace House, Leslie, Fifeshire, Scotland, May 7.

Doppler's Principle.

In answer to a correspondent who has met with a difficulty in the consideration of Doppler's principle, I may say that I think I fairly solved the difficulty in a paper delivered last year before the University College Chemical and Physical Society. In cases (1) and (2) of your correspondent, viz. approach or recession of observer, source and medium being at rest, the correct formula is $n' = n\frac{a \pm v}{a}$; and in cases (3) and (4), viz. approach and recession of source, observer and medium at rest, it is $n' = n\frac{a}{a \mp v}$, n' = the new, and n the old frequency of vibration of the note heard. It should be remarked, however, that in all practical cases, the two formulæ give very nearly the same result; but if the velocity v is very great, the case is entirely different. Suppose, for instance, in cases (1) and (2) that v = velocity of sound a, then $n' = 2n$ for approach, and 0 for recession of the observer. The correctness of these results is obvious without the aid of any formula. Again, in cases (3) and (4) suppose $v = a$, then $n' = \infty$ for approach, and $\frac{n}{2}$ for recession of the source of sound. The effect of an infinite number of waves striking the ear at the same moment would be simply that nothing would be heard. It would be interesting to notice the change in pitch of the whistle of a rifle-bullet passing near an observer. Ganot's formula is correct for cases (1) and (2), and Prof. Everett's for cases (3) and (4); the proofs are very simple, and may be easily thought out. When the observer and the source of sound both move, the two formulæ should be applied separately when a very accurate result is desired. These conclusions have been confirmed by Dr. Fison, of University College. I had not considered the effect of the motion of the medium, but it appears to me, after a little reflection, that this would increase or diminish the velocity of the sound, and the wave-length, in the same proportion, leaving the pitch unaltered; the velocity of the medium should therefore be added to or subtracted from a in the formula.

University College, May 5. E. P. Perman.

"Index Generum et Specierum Animalium."

Naturalists have long needed a reference book to the names of genera and species. Such a want has already been partially supplied by Agassiz, Bronn, Morris, Marschall, Scudder, Waterhouse, and others—only Bronn and Morris having attempted palæontological species—but no one book including references to all names given to living and fossil animals has yet been attempted. Botanists, more fortunate, will soon possess Daydon Jackson's index to flowering plants. The idea has therefore suggested itself to me to begin at the end of June next, such an "Index Generum et Specierum Animalium," taking the following rules for guidance :—

(1) The earliest reference is to date from the twelfth edition of Linnæus, 1766.

(2) The last reference to close with December 31, 1899.

(3) The names of genera and species to be given in a single alphabetical sequence, and accompanied by a reference to the original source.

(4) The names of species of each genus to be also quoted in alphabetical order under that genus.

(5) No attempt at synonymy to be given; but, to assist reference, the various genera in which a species has from time to time been placed, to be indicated under that species.

(6) Pre-Linnæan names to be quoted as founded by the author first using them after 1766 :—*e.g. Echinocorys*, Leske, 1778 (*ex* Klein, 1734). Should a pre-Linnæan species or genus have been re-named after 1766, before the post-Linnæan use of that pre-Linnæan name, the new name is to stand. [References will be given to Artedi, Brisson, and Scopoli, in accordance with British Association rules.]

Among the many offers of assistance, that of Prof. Flower, F.R.S., Dr. Günther, F.R.S., and Dr. Henry Woodward, F.R.S., who have promised the necessary space for the storage of the MS. in the Natural History Museum, is most valuable, as it practically ensures safety from fire, and renders the MS. easily accessible to those wishing to consult it while still imperfect.

The contribution of inaugural addresses, theses, or other publications difficult to obtain, would be of great assistance; and, after use, such pamphlets would be handed over to the library at the Museum.

Any suggestions for the improvement of this plan, before the commencement of the undertaking, would be gladly received and carefully considered.

Appended is a rough outline of the scheme :—

[cordatus -a, -um]
—— Amphidetus (Penn.) Düb. and Koren, Zool. Bid. 285 1844
[*v.* Echinus]
—— Amphidotus (Penn.) E. Forbes, Brit. Starf. 190, fig. 1841
[*v.* Echinus]
—— Echinocardium (Penn.) J. E. Gray, Cat. R. Ech. 43 1855
[*v.* Echinus]
—— Echinus, Pennant, Brit. Zool. iv. 58, xxxiv. 2, xxxvi. 2 1777
[*v.* also Amphidetus, Amphidotus, Echinocardium, Spatangus]
—— Spatangus (Penn.) Flem. Brit. Anim. 480 ... 1828
[*v.* Echinus]
Cordia, Stål, Hem. Afric. iv. 78 ... ... Hem. 1866
[albilaterata, peragrans.]
Cordienia, A. Rouault, B. S. géol. France, v. 207.. Gast. 1848
[biaritziana, iberica, palensis, pyrenaica, all *nom. nud.*]

Charles Davies Sherborn.

540 King's Road, London, S.W.

"The Anatomy of the Frog."

In your notice of the above work, in Nature of the 8th inst., you are pleased to express a favourable opinion of the wood engravings. As the heading of the article might lead your readers to imagine that these, in addition to the coloured plates, were all executed by Hofmann, of Bavaria, I think they, as well as yourself, will be pleased to know that all the *new* blocks, numbering upwards of one hundred, were engraved by

172 Strand, London. T. P. Collings.

COLOUR-VISION AND COLOUR-BLINDNESS.[1]

IT is a matter of familiar knowledge that the sense of vision is called into activity by the formation, on the retina or internal nervous expansion of the eye, of an inverted optical image of external objects—an image precisely analogous to that of the photographic camera. The retina lines the interior of the eyeball over somewhat more than its posterior hemisphere. It is a very delicate transparent membrane, about one-fifth of a millimetre in thickness at its thickest part, near the entrance of the optic nerve, and it gradually diminishes to less than half that thickness at its periphery. It is resolvable by the microscope into ten layers, which are united together by a web of connective tissue, which also carries blood-vessels to minister to the maintenance of the structure. I need only refer to two of these layers: the anterior or fibre-layer, mainly composed of the fibres of the optic nerve, which spread out radially from their point of entrance in every direction, except where they curve around the central portion of the membrane; and the perceptive layer, which, as viewed from the interior of the eyeball, may be likened to an extremely fine mosaic, each individual piece of which is in communication with a nerve fibre, by which the impressions made upon it are conducted to the brain. The terminals of the perceptive layer are of two kinds, called respectively rods and cones; the former, as the name implies, being cylindrical in shape, and the latter conical. The bases of the cones are directed towards the interior of the eye, so as to receive the light; and it is probable that each cone may be regarded as a collecting apparatus, calculated to gather together the light which it receives, and to concentrate this light upon its deeper and more slender portion, or posterior limb, which is believed to be the portion of the whole structure which is really sensitive to luminous impressions. The distribution of the two elements differs greatly in different animals; and the differences point to corresponding differences in function. The cones are more sensitive than the rods, and minister to a higher acuteness of vision. In the human eye, there is a small central region in which the perceptive layer consists of cones only, a region which the fibres avoid by curving round it, and in which the other layers of the retina are much thinner than elsewhere, so as to leave a depression, and are stained of a lemon-yellow colour. In a zone immediately around this yellow spot each cone is surrounded by a single circle of rods; and, as we proceed outwards towards the periphery of the retina, the circle of rods around each cone becomes successively double, triple, quadruple, or even more numerous. The yellow spot receives the image of the object to which the eye is actually directed, while the images of surrounding objects fall upon zones which surround the yellow spot; and the result of this arrangement is that, generally speaking, the distinctness of vision diminishes in proportion to the distance of the image of the object from the retinal centre. The consequent effect has been well described by saying that what we see resembles a picture, the central part of which is exquisitely finished, while the parts around the centre are only roughly sketched in. We are conscious that these outer parts are there; but, if we desire to see them accurately, they must be made the objects of direct vision in their turn.

The indistinctness with which we see lateral objects is so completely neutralized by the quick mobility of the eyes, and by the manner in which they range almost unconsciously over the whole field of vision, that it seldom or never forces itself upon the attention. It may be conveniently displayed by means of an instrument called a perimeter, which enables the observer to look steadily at a central spot, while a second spot, or other object, is moved along an arc, in any meridian, from the circumference of the field of view towards the centre, or *vice versâ*. Slight differences will be found between individuals; but, speaking generally, a capital letter one-third of an inch high, which is legible by direct vision at a distance of sixteen feet, and is recognizable as a dark object at 40° or 50° from the fixing point, will not become legible, at a distance of one foot, until it arrives within about 10°.

The image formed upon the retina is rendered visible by two different conditions—that is to say, by differences in the amount of light which enters into the formation of its different parts, and by differences in the quality of this light, that is, in its colour. The former conditions are fulfilled by an engraving, the latter by a painting. It is with the latter conditions only, and with the power of perceiving them, that we are concerned this evening.

Before such an audience as that which I have the honour to address, it is unnecessary to say more about colour than that it depends upon the power, possessed by the objects which we describe as coloured, to absorb and retain certain portions of white or other mixed light, and to reflect or transmit other portions. The resulting effect of colour is the impression produced upon the eye or upon the brain by the waves of light which are left, after the process of selective absorption has been accomplished. Some substances absorb two of the three fundamental colours of the solar spectrum, others absorb one only, others absorb portions of one or more. Whatever remains is transmitted through the media of the eye; and, in the great majority of the human race, suffices to excite the retina to a characteristic kind of activity. Few things are more curious than the multitude of different colour sensations which may be produced by the varying combinations of the three simple elements, red, green, and violet; but this is a part of the subject into which it would be impossible for me now to enter, and with which most of those who hear me must already be perfectly familiar.

Apart from the effect of colour as one of the chief sources of beauty in the world, it is manifest that the power of distinguishing it adds greatly to the acuteness of vision. Objects which differ from their surroundings by differences of colour are far more conspicuous than those which differ only by differences of light and shade. Flowers are much indebted to their brilliant colouring for the visits of the insects by which they are fertilized; and creatures which are the prey of others find their best protection in a resemblance to the colours of their environment. It is probably a universal truth that the organs of colour-perception are more highly specialized, and that the sense of colour is more developed, in all animals, in precise proportion to the general acuteness of vision of each.

From a variety of considerations, into which time will not allow me to enter, it has been concluded that the sense of colour is an endowment of the retinal cones, and that the rods are sensitive only to differences in the quantity of the incident light, without regard to its quality. Nocturnal mammals, such as mice, bats, and hedgehogs, have no cones; and cones are less developed in nocturnal birds than in diurnal ones. Certain limitations of the human colour sense may almost be inferred from the anatomy of the retina. It is found, as that anatomy would lead us to suppose, that complete colour sense exists only in the retinal centre, or in and immediately around the yellow spot region, and that it diminishes as we pass away from this centre towards the periphery. The precise facts are more difficult to ascertain than might be supposed; for, although it is easy to bring coloured objects from the circumference to the centre of the field of vision on the perimeter, it is by no means easy to be quite sure of the point at which the true colour of the advancing

[1] Lecture delivered at the Royal Institution, on Friday, May 9, 1890, by Mr. R. Brudenell Carter.

object can first be said to be distinctly seen. Much depends, moreover, on the size of this advancing object; because, the larger it is, the sooner will its image fall upon some of the more sparsely distributed cones of the peripheral portion of the retina. Testing the matter upon myself with coloured cards of the size of a man's visiting card, I find that I am conscious of red or blue at about 40° from the fixing point, but not of green until it comes within about 30°; while, if I take three spots, respectively of bright red, bright green, and bright blue, each half a centimetre in diameter, and separated from its neighbour on either side by an interval of half a centimetre, spots which would be visible as distinct and separate objects at eight metres, I cannot fairly and distinctly see all three colours until they come within 10° of the centre. Beyond 40°, albeit with slight differences between individuals, and on different meridians for the same individual, colours are only seen by the degree of their luminosity—that is, they appear as light spots if upon a dark ground, and as dark spots if upon a light ground. Speaking generally, therefore, it may be said that human vision is only trichromatic, or complete for the three fundamental colours of the solar spectrum, over a small central area, which certainly does not cover more than 30° of the field; that it is bi-chromatic, or limited to red and violet, over an annulus outside this central area; and that it is limited to light and shade from thence to the outermost limits of the field.

The nature and limitations of the colour-sense in man long ago suggested to Thomas Young that the retina might contain three sets of fibres, each set capable of responding to only one of the fundamental colours; or, in other words, that there are special nerve fibres for red, special nerve fibres for green, and special nerve fibres for violet. It has also been assumed that the differences between these fibres might essentially consist in the ability of each set to respond only to light-vibrations of a certain wave-length, much as a tuned string will only respond to a note with which it is in unison. In the human subject, so far as has yet been ascertained, no optical differences between the cones are discoverable; but the analogy of the ear, and the facts which have been supplied by comparative anatomy, combine to render Young's hypothesis exceedingly probable, and it is generally accepted, at least provisionally, as the only one which furnishes an explanation of the facts. It implies that elements of all three varieties are present in the central portion of the retina; that elements sensitive to green are absent from an annulus around the centre; and that the peripheral portions are destitute of any elements by which colour-sense can be called into activity.

According to the observation already made, that the highest degree of acuteness of vision is necessarily attended by a corresponding acuteness of colour-sense, we should naturally expect to find such a highly-developed colour-sense in birds, many of which appear, as regards visual power, to surpass all other creatures. I need not dwell upon the often-described acuteness of vision of vultures, or upon the vision of fishing birds; but may pass on to remark that the acuteness of their vision appears not only to be unquestionable, but also to be much more widely diffused over the retina than is the case with man. If we watch domestic poultry, or pigeons, feeding, we shall frequently see a bird, when busily picking up food immediately in front of its beak, suddenly make a lateral dart to some grain lying sideways to its line of sight, which would have been practically invisible to a human eye looking in the same direction as that of the fowl. When we examine the retina the explanation both of the acuteness of vision and of its distribution becomes at once apparent. In birds, in some reptiles, and in fishes, not only are cones distributed over the retina much more abundantly and more evenly than in man, but the cones are provided with coloured globules, droplets of coloured oil, at their apices, through which the light entering them must pass before it can excite sensation, and which are practically impervious to any colour but their own. Each globule is so placed as to intervene between what is regarded as the collecting portion of the cone and what is regarded as its perceptive portion in such a way that the latter can only receive colour which is capable of passing through the globule. The retinæ of many birds, especially of the finch, the pigeon, and the domestic fowl, have been carefully examined by Dr. Waelchli, who finds that near the centre green is the predominant colour of the cones, while among the green cones red and orange ones are somewhat sparingly interspersed, and are nearly always arranged alternately, a red cone between two orange ones, and *vice versâ*. In a surrounding portion, called by Dr. Waelchli the red zone, the red and orange cones are arranged in chains, and are larger and more numerous than near the yellow spot; the green ones are of smaller size, and fill up the interspaces. Near the periphery the cones are scattered, the three colours about equally numerous and of equal size, while a few colourless cones are also seen. Dr. Waelchli examined the optical properties of the coloured cones by means of the micro-spectroscope, and found, as the colours would lead us to suppose, that they transmitted only the corresponding portions of the spectrum; and it would almost seem, excepting for the few colourless cones at the peripheral part of the retina, that the birds examined must have been unable to see blue, the whole of which would be absorbed by their colour globules. It would be necessary to be thoroughly acquainted with their food in order to understand any advantage which the birds in question may derive from the predominance of green, red, and orange globules over others; but it is impossible to consider the structure thus described without coming to the conclusion that the birds in which it exists must have a very acute sense of the colours corresponding to the globules with which they are so abundantly provided, and that this colour-sense, instead of being localized in the centre, as in the human eye, must be diffused over a very large portion of the retina. Dr. Waelchli points out that the coloration of the yellow spot in man must, to a certain extent, exclude blue from the central and most sensitive portion of his retina.

It is hardly necessary to mention how completely the high differentiation of the cones in the creatures referred to tends to support the hypothesis of Young, that a similar differentiation, although not equally manifest, exists also in man. If this be so, we must conclude that the region of the yellow spot contains cones, some of which are capable of being called into activity by red, others by green, and others by violet; that a surrounding annulus contains no cones sensitive to green, but such as are sensitive to red or to violet only; and that, beyond and around this latter region, such cones as may exist are not sensitive to any colour, but, like the rods, only to differences in the amount of light. When cones of only one kind are called into activity, the sensation produced is named red, green, or violet; and, when all three varieties are stimulated in about an equal degree, the sensation produced is called white. In the same way, the innumerable intermediate colour-sensations of which the normal eye is susceptible, must be ascribed to stimulation of the three varieties of cones in unequal degrees.

The conditions of colour-sense which, in the human race, or at least in civilized man, exist normally in outer zones of the retina, are found, in a few individuals, to exist also in the centre. There are persons in whom the region of the yellow spot is absolutely insensitive to colour, and recognizes only differences in the amount or quantity of light. To such persons, the term "colour-blind" ought perhaps in strictness to be limited; but the individuals in question are so rare that they are hardly entitled to a monopoly of an appellation which is conveniently applied also to others. The totally colour-blind would see a coloured picture as if it were an engraving, or a drawing in black and white, and would perceive differences between its parts only in the degree in which they differed in brightness.

A more common condition is the existence, in the centre of the retina, of a kind of vision like that which normally exists in the zone next surrounding it—that is, a blindness to green. Persons who are blind to green appear to see violet and yellow much as these are seen by the normal-sighted; and they can see red, but they cannot distinguish it from green. Others, and this form is more common than the preceding, are blind to red; and a very small number of persons are blind to violet. Such blindness to one of the fundamental colours may be either complete or incomplete—that is to say, the power of the colour in question to excite its proper sensation may be either absent or feeble. In some cases, the defect is so moderate in degree as to be adequately described by the phrase "defective colour-sense."

The experiments of Helmholtz upon colour led him to supplement the original hypothesis of Young by the supposition that the special nerve elements excited by any one colour are also excited in some degree by each of the other two, but that they respond by the sensation appropriate to themselves, and not by that appropriate to the colour by which they are thus feebly excited. This, which is often called the Young-Helmholtz hypothesis, assumes that the pure red of the spectrum, while it mainly stimulates the fibres sensitive to red, stimulates in a less degree those which are sensitive to green, and in a still less degree those which are sensitive to violet, the resulting sensation being red. Pure green stimulates strongly the green-perceptive fibres, and stimulates slightly both the red-perceptive and the violet-perceptive—resulting sensation, green. Pure violet stimulates strongly the violet-perceptive fibres, less strongly the green-perceptive, least strongly the red-perceptive—resulting sensation, violet. When all three sets of fibres are stimulated at once, the resulting sensation is white; and when a normal eye is directed to the spectrum, the region of greatest luminosity is in the middle of the yellow; because, while here both the green-perceptive and the red-perceptive fibres are stimulated in a high degree, the violet-perceptive are also stimulated in some degree.

According to this view of the case, the person who is red-blind, or in whom the red-perceptive fibres are wanting or paralyzed, has only two fundamental colours in the spectrum instead of three. Spectral red, nevertheless, is not invisible to him, because it feebly excites his green-perceptive fibres, and hence appears as a saturated green of feeble luminosity; saturated, because it scarcely at all excites the violet-perceptive fibres. The brightest part of the spectrum, instead of being in the yellow, is in the blue-green, because here both sets of sensitive fibres are stimulated. In the case of the green-blind, in whom the fibres perceptive of green are supposed to be wanting or paralyzed, the only stimulation produced by spectral green is that of the red-perceptive and of the violet-perceptive fibres; and where these are equally stimulated, we obtain the white of the green-blind, which, to ordinary eyes, is a sort of rose-colour, a mixture of red and violet. In like manner, the white of the red-blind is a mixture of green and violet; and, if we consider the facts, we shall see that spectral red, which somewhat feebly stimulates the green-perceptive fibres of the normal eye, and spectral green, which somewhat feebly stimulates the red-perceptive fibres of the normal, and also of the green-blind eye, must appear to the green-blind to be one and the same colour, differing only in luminosity, and that in an opposite sense to the perception of the red-blind. In other words, red and green are undistinguishable from each other, as colours, alike to the red-blind and to the green-blind; but to the former the red, and to the latter the green, appears, as compared with the other, to be of feeble luminosity. In either case, the two are only lighter and darker shades of the same colour. The conditions of violet-blindness are analogous, but the defect itself is very rare; and, as it is of small industrial importance, it has attracted but a small degree of attention.

Very extensive investigations, conducted during the last few years both in Europe and in America, have shown that those which may be called the common forms of colour-blindness, the blindness to red and to green, exist in about four per cent. of the male population, and in perhaps one per thousand of females. Among the rest, there are slight differences of colour-sense, partly due to differences of habit and training, but of little or no practical importance. One such difference, to which Lord Rayleigh was the first to direct attention, has reference to yellow. The pure yellow of the spectrum may, as is generally known, be precisely matched by a mixture of spectral red with spectral green; but the proportions in which the mixture should be made differ within certain limits for different people. The difference must, I think, depend upon differences in the pigmentation of the yellow spot, rather than upon any defect in the nervous apparatus of the colour-sense. There is a very ingenious instrument, invented by Mr. Lovibond, and called by him the "tintometer," which allows the colour of any object to be accurately matched by combinations of coloured glass, and to be expressed in terms of the combination. In using this instrument, we not only find slight differences in the combinations required by different people, but also in the combinations required by the two eyes of the same person. Here, again, I think the differences must be due either to differences in the pigmentation of the yellow spot, or possibly also to differences in the colour of the internal lenses of the several eyes, the lens, as is well known, being usually somewhat yellow after middle age. The differences are plainly manifest in comparing persons all of whom possess tri-chromatic vision, and are not sufficient in degree to be of any practical importance.

Taking the ordinary case of a red-blind or of a green-blind person, it is interesting to speculate upon the appearance which the world must present to them. Being insensible to one of the fundamental colours of the spectrum, they must lose, roughly speaking, one-third of the luminosity of Nature; unless, as is possible, the deficiency is made good to them by increased acuteness of perception to the colours which they see. Whether they see white as we see it, or as we see the mixtures of red and violet, or of green and violet, which they make to match with it, we can only conjecture, on account of the inadequacy of language to convey any accurate idea of sensation. We have all heard of the blind man who concluded, from the attempts made to describe scarlet to him, that it was like the sound of a trumpet. If we take a heap of coloured wools, and look at them first through a glass of peacock-blue, by which the red rays are filtered out, and next through a purple glass, by which a large proportion of the green will be filtered out, we may presume that, under the first condition, the wools will appear much as they would do to the red-blind; and, under the second, much as they would do to the green-blind. It will be observed that the appearances differ in the two conditions, but that, in both, red and green are practically undistinguishable from each other, and appear as the same colour, but of different luminosity.

Prior to reflection, and still more, prior to experience, we should be apt to conjecture that the existence of colour-blindness in any individual could not remain concealed, either from himself or from those around him; but such a conjecture would be directly at variance with the truth. Just as it was reserved for Mariotte, in the reign of Charles II., to discover that there is, in the field of vision of every eye, a lacuna or blind spot, corresponding with the entrance of the optic nerve, so it was reserved for a still later generation to discover the existence of so common a defect as colour-blindness. The first recorded case was described to Dr. Priestley by Mr. Huddart, in 1777, and was that of a man named Harris, a shoemaker at Maryport in Cumberland, who had also a colour-blind brother, a mariner. Soon afterwards, the case of Dalton, the chemist, was fully described, and led to the discovery of other examples of a similar kind. The condition was still, however, looked upon as a very exceptional one; insomuch that the name of "Daltonism" was proposed for it, and is still generally used in France as a synonym for colour-blindness. Such use is objectionable, not only because it is undesirable thus to perpetuate the memory of the physical infirmity of an eminent philosopher, but also because Dalton was a red-blind, so that the name could only be correctly applied to his particular form of defect.

Colour-blindness often escapes detection on account of the use of colour-names by the colour-blind in the same manner as that in which they hear them used by other people. Children learn from the talk of those around them, that it is proper to describe grass as green, and bricks or cherries as red; and they follow this usage, although the difference may appear to them so slight that their interpretation of either colour-name may be simply as a lighter or darker shade of the other. When they make mistakes, they are laughed at, and thought careless, or to be merely using colour-names incorrectly; and a common result is that they rather avoid such names, and shrink from committing themselves to statements about colour. Dr. Joy Jefferies gives an interesting description of the almost unconscious devices practised by the colour-blind in this way. He says:—

"The colour-blind, who are quick-witted enough to discover early that something is wrong with their vision by the smiles of their listeners when they mention this or that object by colour, are equally quick-witted in avoiding so doing. They have found that there are names of certain attributes they cannot comprehend, and hence must let alone. They learn, also, what we forget, that so many objects of every-day life always have the same colour, as red tiles or bricks, and the colour names of these they use with freedom; whilst they often, even unconsciously, are cautious not to name the colour of a new object till they have heard it applied, after which it is a mere matter of memory stimulated by a consciousness of defect. I have often recalled to the colour-blind their own acts and words, and surprised them by an exposure of the mental jugglery they employed to escape detection, and of which they were almost unaware, so much had it become matter of habit. Another important point is, that as violet-blindness is very rare, the vast majority of defective eyes are red or green blind. These persons see violet and yellow as the normal-eyed, and they naturally apply these colour-names correctly. When, therefore, they fail in red or green, a casual observer attributes it to simple carelessness—hence a very ready avoidance of detection. It does not seem possible that anyone who sees so much correctly, and whose ideas of colour so correspond with our own, cannot be equally correct throughout, if they will but take the pains to notice and learn."

When the colour-blind are placed in positions which compel them to select colours for themselves and others, or when, as sometimes happens, they are not sensitive with regard to their defect, but rather find amusement in the astonishment which it produces among the colour-seeing, the results which occasionally follow are apt to be curious. They have often been rendered still more curious, by having been the unconscious work of members of the Society of Friends. Colour-blindness is a structural peculiarity, constituting what may be called a variety of the human race; and, like other varieties, it is liable to be handed down to posterity. Hence, if the variety occurs in a person belonging to a community which is small by comparison with the nation, and among whose members there is frequent inter-marriage, it has an increased probability of being reproduced; and thus, while many of the best known of the early examples of colour-blindness, including that of Dalton himself, were furnished by the Society of Friends, the examinations of large numbers of scholars and others, conducted during the last few years, have shown that, in this country, colour-blindness is more common among Jews than among the general population. The Jews have no peculiarities of costume; but the spectacle, which has more than once been witnessed, of a venerable Quaker who had clothed himself in bright green or in vivid scarlet, could scarcely fail to excite the derision of the unreflecting. Time does not allow me to relate the many errors of the colour-blind which have been recorded; but there is an instance of a clerk in a Government office, whose duty it was to tick certain entries, in relation to their subject-matter, with ink of one or of another colour, and whose accuracy was dependent upon the order in which his ink-bottles were ranged in front of him. This order having been accidentally disturbed, great confusion was produced by his mistakes, and it was a long time before these were satisfactorily accounted for. An official of the Prussian Post-Office, again, who was accustomed to sell stamps of different values and colours, was frequently wrong in his cash, his errors being as often against himself as in his favour, so as to exclude any suspicion of dishonesty. His seeming carelessness was at last explained by the discovery of his colour-blindness, and he was relieved of a duty which it was impossible for him to discharge without falling into error.

The colour-mistakes of former years were, however, of little moment when compared with those now liable to be committed by engine-drivers and mariners. The avoidance of collisions at sea and on railways depends largely on the power promptly to recognize the colours of signals; and the colours most available for signalling purposes are red and green, or precisely those between which the sufferers from the two most common forms of colour-blindness are unable with any certainty to discriminate. About thirteen years ago there was a serious railway accident in Sweden, and, in the investigation subsequent to this accident, there were some remarkable discrepancies in the evidence given with regard to the colour of the signals which had been displayed. Prof. Holmgren, of the University of Upsala, had his attention called to this discrepancy, and he found, on further examination, that the witness whose assertions about the signals differed from those of other people was actually colour-blind. From this incident arose Prof. Holmgren's great interest in the subject, and he did not rest until he had obtained the enactment of a law under which no one can be taken into the employment of a Swedish railway until his colour-vision has been tested, and has been found to be sufficient for the duties he will be called upon to perform. The example thus set by Sweden has been followed, more or less, by other countries, and especially, thanks to the untiring labours of Dr. Joy Jeffries, of Boston, by several of the United States; while at the same time much evidence has been collected to show the connection between railway and marine accidents and the defect.

It has been found, by very extensive and carefully conducted examinations of large bodies of men, soldiers, policemen, the workers in great industrial establishments, and so forth, as well as of children in many schools, that colour-blindness exists in a noticeable degree, as I have already said, in about four per cent. of the male industrial population in civilized countries, and in about one per thousand of females. Among the males of the more highly educated classes, taking Eton boys as an example, the colour-blind are only between two and three per cent., and perhaps nearer to two than to three.

Whether a similar difference exists between females of different classes, we have no statistics to establish. The condition of colour-blindness is absolutely incurable, absolutely incapable of modification by training or exercise, in the case of the individual; although the comparative immunity of the female sex justifies the suggestion that it may possibly be due to training throughout successive generations, on account of the more habitual occupation of the female eyes about colour in relation to costume. However this may be, in the individual, as I have said, the defect is unalterable; and if the difference between red and green is uncertain at eight years of age, it will be equally uncertain at eighty. Hence the existence of colour-blindness, among those who have to control the movements of ships or of railway trains, constitutes a real danger to the public; and it is highly important that the colour-blind, in their own interests as well as in those of others, should be excluded from employments the duties of which they are unfit to discharge.

The attempts hitherto made in this country to exclude the colour-blind from railway and marine employment have not been by any means successful. As far as the merchant navy is concerned, so-called examinations have been conducted by the Board of Trade, with results which can only be described as ludicrous. Candidates have been "plucked" in colour at one examination, and permitted to pass at a subsequent one; as if correct colour-vision were something which could be acquired. Such candidates were either improperly rejected on the first occasion, or improperly accepted on the second. On English railways there has been no uniformity in the methods of testing; except, in so far as I am acquainted with them, that they have been almost uniformly misleading, calculated to lead to the imputation of colour-blindness where it did not exist, and to leave it undiscovered where it did. In these circumstances it is not surprising that great discontent should have arisen among railway men in relation to the subject; and this discontent has led, indirectly, to the appointment of a Committee by the Royal Society, with the sanction of the Board of Trade, for the purpose of investigating the whole question as completely as may be possible.

It is perhaps worth while, before proceeding to describe the manner in which the colour-sense of large bodies of men should be tested for industrial purposes, to say something as to the amount of danger which colour-blindness produces. A locomotive, as we all know, is under the charge of two men—the driver and the fireman. In a staff of one thousand of each, allotted to one thousand locomotives, we should expect, in the absence of any efficient method of examination, to find forty colour-blind drivers, and forty colour-blind firemen. The chances would be one in twenty-five that either the driver or the fireman on any particular engine would be colour-blind; they would be one in 625 that both would be colour-blind. These figures appear to show a greater risk of accident than we find realized in actual working, and it is manifest that there are compensations to be taken into account. In the first place, the term "colour-blind" is itself in some degree misleading; for it must be remembered that the signals to which the colour-blind person is said to be "blind" are not invisible to him. To the red-blind, the red light is a less luminous green; to the green-blind, the green light is a less luminous red. The danger arises because the apparent differences are not sufficiently characteristic to lead to certain and prompt identification in all states of illumination and of atmosphere. It must be admitted, therefore, that a colour-blind driver may be at work for a long time without mistakes; and it is probable, knowing as he must that the differences between different signal lights appear to him to be only trivial, that he will exercise extreme caution. Then it must be remembered that lights never appear to an engine-driver in unexpected places. Before being intrusted with a train, he is taken over the line, and is shown the precise position of every light. If a light did not appear where it was due, he would naturally ask his fireman to aid in the look-out. It must be also remembered that to overrun a danger signal does not of necessity imply a collision. A driver may overrun the signal, and after doing so may see a train or other obstruction on the line, and may stop in time to avoid an accident. In such a case, he would probably be reported and fined for overrunning the signal; and, if the same thing occurred again, he would be dismissed for his assumed carelessness, probably with no suspicion of his defect. Colour-blind firemen are unquestionably thus driven out of the service by the complaints of their drivers; and none but railway officials know how many cases of overrunning signals, followed by disputes as to what the signals actually were, occur in the course of a year's work. I have never heard of an instance in this country, in which, after a railway accident, the colour-vision of the driver concerned, or of his fireman, has been tested by an expert, on the part either of the Board of Trade or of the Company; but a fireman in the United States has recently recovered heavy damages from the Company for the loss of one of his legs in a collision which was proved to have been occasioned by the colour-blindness of the driver. Looking at the whole question, I feel that the danger on railways is a real one, but that it is minimized by the several considerations to which I have referred, and that it is much smaller than the frequency of the defect might lead us to think likely.

At sea, the danger is much more formidable. The lights appear at all sorts of times and places, and there may be only one responsible person on the look-out. Mr. Bickerton, of Liverpool, has lately published accounts of three cases in which the colour-blindness of officers of the mercantile marine, all of whom had passed the Board of Trade examination, was accidentally discovered by the captains being on deck when the officers in question gave wrong orders consequent upon mistaking the light shown by an approaching vessel. The loss of the *Ville du Havre* was almost certainly due to colour-blindness; and a very fatal collision in American waters, some years ago, between the *Isaac Bell* and the *Lumberman*, was traced, long after the event, to the colour-blindness of a pilot, who had been unjustly accused of being drunk at the time of the occurrence. In how many instances colour-blindness has been the unsuspected cause of wrecks and other calamities at sea, it is impossible to do more than conjecture.

It is necessary, then, alike in the public interest and in the interest of the colour-blind, who have doubtless often suffered in the misfortunes which their defects have produced, to detect them in time to prevent them from entering into the marine and railway services; and the next question is, how this detection should be accomplished. We have to distinguish the colour-blind from the colour-sighted; but we must be careful not to confound colour-blindness with the much more common condition of colour-ignorance.

It would surprise many people, more especially many ladies, to discover the extent to which sheer ignorance of colour prevails among boys and men of the labouring classes. Many, who can see colours perfectly, and who would never be in the least danger of mistaking a railway signal, are quite unable to name colours or to describe them; and they are sometimes unable to perceive, for want of education of a faculty which they notwithstanding possess, anything like fine shades of difference. Mr. Gladstone once published a paper on the scanty and uncertain colour-nomenclature of the Homeric poems; and he might have found very similar examples among his own contemporaries and in his own country. I have lately seen a pattern card of coloured silks, issued by a Lyons manufacturer, which contains samples of two thousand different colours, each with its more or less appropriate name. There is here a larger colour-vocabulary than the entire vocabulary, for the expression of all his knowledge and of all his ideas, which is possessed by an average engine-driver or fireman; and, just as most of us would be ignorant of the names of the immense majority of the colours displayed on that card, so hundreds of men and boys among the labouring classes, especially in large towns, where the opportunities of education by the colours of flowers and insects are very limited, are ignorant of the names of colours which persons of ordinary cultivation mention constantly in their daily talk, and expect their children to pick up and to understand unconsciously. It is among people thus ignorant that the officials of the Board of Trade, and of railways, have been most successful in finding their supposed colour-blind persons; and these persons, who would never have been pronounced colour-blind by an expert, have been able, as soon as they have paid a little attention to the observation and naming of colour, to pass an official examination triumphantly. The sense of colour presents many analogies to that of hearing. Some people can hear a higher or a lower note than others, the difference depending upon structure, and being incapable of alteration. No one who cannot hear a note of a certain pitch can ever be trained to do so; but, within the original auditory limits of each individual, the sense of hearing may be greatly improved by cultivation. In like manner, a person who is blind to red or green must remain so; but one whose colour-sense is merely undeveloped by want of cultivation may have its acuteness for fine differences very considerably increased.

In order to test colour-vision for railway and marine purposes, the first suggestion which would occur to many people would be to employ as objects the flags and signal lanterns which are used in actual working. I have heard apparently sensible people use, with reference to such a procedure, the phrase upon which Faraday was wont to pour ridicule, and to say that the fitness of the suggested method "stands to reason." To be effectual, such a test must be applied in different states of atmosphere, with coloured glasses of various tints, with various degrees of illumination, and with the objects at various distances; so that much time would be required in order to exhaust all the conditions under which railway signals may present themselves. This being done, the examinee must be either right or wrong each time. He has always an even chance of being right; and it would be an insoluble problem to discover how many correct answers were due to accident, or how many incorrect ones might be attributed to nervousness or to confusion of names.

We must remember that what is required is to detect a colour-blind person against his will; and to ascertain, not whether he describes a given signal rightly or wrongly on a particular occasion, but whether he can safely be trusted to distinguish correctly between signals on all occasions. We want, in short, to ascertain the state of his colour-vision generally; and hence to infer his fitness or unfitness to discharge the duties of a particular occupation.

For the accomplishment of this object, we do not in the least want to know what the examinee calls colours, but only how he sees them, what colours appear to him to be alike and what appear to be unlike; and the only way of attaining this knowledge with certainty is to cause him to make matches between coloured objects, to put those together which appear to him to be essentially the same, and to separate those which appear to him to be essentially different. This principle of testing was first laid down by Seebeck, who required from examinees a complete arrangement of a large number of coloured objects; but it has been greatly simplified and improved by Prof. Holmgren, who pointed out that such a complete arrangement was superfluous, and that the only thing required was to cause the examinee to make matches to certain test colours, and, for this purpose, to select from a heap which contained not only such matches but also the colours which the colour-blind were liable to confuse with them.

After many trials, Holmgren finally selected skeins of Berlin wool as the material best suited for this purpose; and his set of wools comprises about 150 skeins. The advantages of his method over every other are that the wool is very cheap, very portable, and always to be obtained in every conceivable colour and shade. The skeins are not lustrous, so that light reflected from the surfaces does not interfere with the accuracy of the observation; and they are very easily picked up and manipulated, much more easily than coloured paper or coloured glass. The person to be tested is placed before a table in good daylight, the table is covered by a white cloth, and the skeins are thrown upon it in a loosely arranged heap. The examiner then selects a skein of pale green, much diluted with white, and throws it down by itself to the left of the heap. The examinee is directed to look at this pattern skein and at the heap, and to pick out from the latter, and to place beside the pattern, as many skeins as he can find which are of the same colour. He is not to be particular about lighter or darker shades, and is not to compare narrowly, or to rummage much amongst the heap, but to select by his eyes, and to use his hands chiefly to change the position of the selected material.

In such circumstances, a person with normal colour-sight will select the greens rapidly and without hesitation, will select nothing else, and will select with a certain readiness and confidence easily recognized by an experienced examiner, and which may even be carried to the extent of neglecting the minute accuracy which a person who distrusts his own colour-sight will frequently endeavour to display. Some normal-sighted people will complete their selection by taking greens which incline to yellow, and greens which incline to blue, while others will reject both; but this is a difference depending sometimes upon imperfect colour education, sometimes upon the interpretation placed upon the directions of the examiner, but the person who so selects sees the green element in the yellow-greens and in the blue-greens, and is not colour-blind. The completely colour-blind, whether to red or to green, will proceed with almost as much speed and confidence as the colour-sighted; and will rapidly pick out a number of drabs, fawns, stone-colours, pinks, or yellows. Between the foregoing classes, we meet with a few people who declare the imperfection of their colour-sense by the extreme care with which they select, by their slowness, by their hesitation, and by their desire to compare this or that skein with the pattern more narrowly than the conditions of the trial permit. They may or may not ultimately add one or more of the confusion colours to the green, but they have a manifest tendency to do so, and a general uncertainty in their choice. One of the great advantages of Holmgren's method over every other is the way in which the examiner is able to judge, not only by the final choice of matches, but also by the manner in which the choice is made, by the action of the hands, and by the gestures and general deportment of the examinee.

When confusion colours have been selected, or when an unnatural slowness and hesitation have been shown in selecting, the examinee must be regarded as either completely or incompletely colour-blind. In order to determine which, and also to which colour he is defective, he is subjected to the second test. For this, the wool is mixed again, and the pattern this time is a skein of light purple—that is, of a mixture of red and violet, much diluted with white. To match this, the colour-blind always selects deeper colours. If he puts only deeper purples, he is incompletely colour-blind. If he takes blue or violet, either with or without purple, he is completely red-blind. If he takes green or gray, or one alone, with or without purple, he is completely green-blind. If he takes red or orange, with or without purple, he is violet-blind. If there be any doubt, the examinee may be subjected to a third test, which is not necessary for the satisfaction of an expert, but which sometimes strengthens the proof in the eyes of a bystander. The pattern for this third test is a skein of bright red, to be used in the same way as the green and the purple. The red-blind selects for this dark greens and browns, which are much darker than the pattern; while the green-blind selects greens and browns which are lighter than the pattern.

The method of examination thus described is, I believe, absolutely trustworthy. It requires no apparatus beyond the bundle of skeins of wool, no arrangements beyond a room with a good window, and a table with a white cloth. In examining large numbers of men, they may be admitted into the room fifty or so at a time, may all receive their instructions together, and may then make their selections one by one, all not yet examined watching the actions of those who come up in their turn, and thus learning how to proceed. The time required for large numbers averages about a minute a person. I have heard and read of instances of colour-blind people who had passed the wool test satisfactorily, and had afterwards been detected by other methods, but I confess that I do not believe in them. I do not believe that in such cases the wool test was applied properly, or in accordance with Holmgren's very precise instructions; and I know that it is often applied in a way which can lead to nothing but erroneous results. Railway foremen, for example, receive out of store a small collection of coloured wools selected on no principle, and they use it by pulling out a single thread, and by asking the examinee, "What colour do you call that?" Men of greater scientific pretensions than railway foremen have not always selected their pattern colours accurately, and have allowed those whom they examined, and passed, to make narrow comparisons between the skeins in all sorts of lights, in a way which should of itself have afforded sufficient evidence of defect.

Although, however, the expert may be fully satisfied by the wool test that the examinee is not capable of distinguishing with certainty between red and green flags or lights in all the circumstances in which they can be displayed, it may still remain for him to satisfy the employer who is not an expert, the railway manager, or the ship-owner, and to convince him that the colour-blind person is unfit for certain kinds of employment. It may be equally necessary to convince other workmen that the examinee has been fairly and rightly dealt with. Both these objects may be easily attained, by the use of slight modifications of the lights which are employed. Lanterns for this special purpose were contrived, some years ago, by Holmgren himself, and by the late Prof. Donders of Utrecht, and what are substantially their contrivances have been brought forward within the last few months as novelties, by gentleman in this country who have re-invented them. The principle of all is the same—namely, that light of varying intensity may be displayed through apertures of varying magnitude, and through coloured glass of varying tints, so as to imitate the appearances of signal lamps at different distances, and under different conditions of illumination, of weather, and of atmosphere. To the colour-blind, the difference between a red light and a green one is not a difference of colour, but of luminosity; the colour to which he is blind appearing the less luminous of the two. He may therefore be correct in his guess as to which of the two is exhibited on any given occasion, and he is by no means certain to mistake one for the other when they are exhibited in immediate succession. His liability to error is chiefly conspicuous when he sees one light only, and when the conditions which govern its luminosity depart in any degree from those to which he is most accustomed. With the lanterns of which I have spoken, it is always possible to deceive a colour-blind person by altering the luminosity of a light without altering its colour. This may be done by diminishing the light behind the glass, by increasing the thickness of the red or green glass, or by placing a piece of neutral tint, more or less dark, in front of either. The most incredulous employer may be convinced, by expedients of this kind, that the colour-blind are not to be relied upon for the safe control of ships or of locomotives. With regard to the whole question, there are many points of great interest, both physical and physiological, which are still more or less uncertain; but the practical elements have, I think, been well-nigh exhausted, and the means of securing safety are fully in the hands of those who choose to master and to employ them. The lanterns, in their various forms, are useful for the purpose of thoroughly exposing the colour-blind, and for bringing home the character of their incapacity to unskilled spectators; but they are both cumbrous and superfluous for the detection of the defect, which may be accomplished with far greater ease, and with equal certainty, by the wool test alone.

I have already mentioned that the examinations which have been conducted in the United States, thanks to the indefatigable labours of Dr. Joy Jeffries, have led to the discovery of an enormous and previously quite unsuspected amount of colour-ignorance, the condition which is frequently mistaken for colour-blindness by the methods of examination which are in favour with railway companies and with the Board of Trade; and this colour-ignorance has been justly regarded as a blot on the American system of national education. It has therefore, in some of the States, led to the adoption of systematic colour-teaching in the schools; and, for this purpose, Dr. Joy Jeffries has introduced a wall-chart and coloured cards. The children are taught, in the first instance, to match the colours in the chart with those of the cards distributed to them; and, when they are tolerably expert at matching, they are further taught the names of the colours. It must, nevertheless, always be remembered that a knowledge of names does not necessarily imply a knowledge of the things designated; and that colour-vision stands in no definite relation to colour-nomenclature. Even this system of teaching may leave a colour-blind pupil undetected.

COMPOUND LOCOMOTIVES.

THE present position of locomotive engineering in this country is of a very interesting nature; owing to the gradual increase of weight of trains hauled and the higher speeds now in use, it has been necessary to increase the power of the locomotive by leaps and bounds to cope with these demands. This naturally has not been done without great scheming on the part of the designers, for, with the standard gauge of railway of 4 feet 8½ inches, the engines are tied down to certain dimensions between the frame plates; in total length, to a certain extent, by the turntables in use; and in height of boiler for reasons of stability. These questions of design are interesting because they are intimately connected with the economical working of the engines, especially in the consumption of fuel, a question which of late years has taken a prominent position in the economical management of locomotives. For several years the highly economical results obtained at sea with the use of high pressures coupled with the compound or triple expansion engine have caused engineers to look in that direction for further improvements, with the result that two different types of compound locomotives were designed, and are considerably past the experimental stage. These engines are now working successfully on two of the English railways, and are being adopted on many foreign ones.

The type of compound locomotives first used in any number is that patented by Mr. F. W. Webb, the able Mechanical Superintendent of the London and North-Western Railway. This design is interesting because it is to a certain extent an example of really original work in locomotive practice. Mr. Webb had several very good ideas to work on in this design, all of very great importance from an engineer's point of view. These ideas were as follows:—The engine must not have a double-throw crank-axle, this being certainly the weak point of all inside-cylinder engines; the coupling rods between driving and trailing wheels must be done away with, since these also sometimes break, and may cause serious accidents. The doing away with the coupling rods enables a longer fire-box to be used, because the coupled wheels should be near together to obtain a minimum length of coupling rod, for reasons of safety. Thus, to design an engine to be more powerful than an ordinary four-coupled express of the North-Western heavy pattern, and having at the same time fewer parts liable to accident, as stated above, requires some clever scheming and much thought. The engine ultimately adopted by Mr. Webb for use on the London and North-Western Railway has three cylinders, viz. two high-pressure cylinders and one low-pressure cylinder. The high-pressure cylinders are placed one on each side of the engine, and are connected to the trailing or hind pair of wheels. The low-pressure cylinder is placed between the frames at the front end of the engine, and is connected with the front pair of driving wheels by a single-throw crank-axle. It will be noticed that in this arrangement each pair of wheels are driving wheels, that the side or coupling rods are done away with, and that the ordinary double-throw crank-axle has given place to a single-throw crank-axle, which may be made of ample dimensions and practically unbreakable. The course of the steam through the cylinders is easily understood: steam passes from the boiler to each high-pressure cylinder, and, after doing a certain amount of work, it is led from each high-pressure cylinder into the steam-chest of the low-pressure cylinder; it is there expanded down to a still lower pressure, and then exhausted finally up the chimney.

The cylinders of the *Dreadnought* type—that is, the most powerful type of the compounds on the London and North-Western Railway—are: high-pressure cylinders, 14 inches in diameter and 24 inches stroke; the low-pressure cylinder has a diameter of 30 inches and 24 inches stroke. These engines are designed in such a manner that, when working at their usual speed, the power developed by the high-pressure cylinders, and applied through the hind pair of wheels, shall be about equal to the power of the low-pressure cylinder, and applied to the front pair of driving wheels.

Through the kindness of Mr. Webb I am able to give an account of the working of a special train, run in order to test the fuel and water consumption of this class of engine.

On April 17, 1887, the engine *Dreadnought*, No. 503, worked a special train of coaches and dynamometer car from Crewe to Wolverton, a distance of 105¾ miles, at a speed of 24 miles per hour, including stoppages, which were made every 15 miles on the journey; 24 cwt. of coal were put into the fire-box during the trip, which gives a consumption of 25·4 lbs. of coal per mile; 2629 gallons of water were evaporated, which equals 9·78 lbs. of water per pound of coal consumed. The weight of the train, exclusive of engine and tender, was 259 tons, 3 cwts. 3 qrs., and the mean weight of engine and tender 62 tons 13 cwts., or a total of 321 tons 16 cwts. 3 qrs. for the whole train. This is equivalent to 4·13 tons of train hauled to 1 ton of engine and tender hauling it, and 1·26 oz. of coal per ton per mile.

The same locomotive worked a similar train between the same points on January 1, 1888, but at a speed of 44 miles per hour, with one stoppage only at Rugby, the results being as follows:—30 cwts. of coal were put into the fire-box during the trip, which gives a consumption of 41·3 lbs. of coal per mile; 3608 gallons of water were evaporated, which equals 8·26 lbs. of water per pound of coal consumed. The weight of the train, exclusive of engine and tender, was 256 tons, 18 cwts., and the mean weight of the engine and tender 62 tons 13 cwts., or a total of 319 tons 11 cwts. for the whole train. This is equivalent to 4·1 tons hauled to 1 ton of engine and tender hauling it, and 2·06 oz. of coal per ton per mile.

When the first trip was made, the weather was warm and dry, but during the latter a hard frost prevailed. With this exception the conditions under which the trips were made were practically alike. The difference in fuel consumption between the two trips may be taken as that due to the difference in speed. There are 77 compound locomotives now at work on the London and North-Western Railway, which have run to the end of December 1889 a total of 13,423,798 miles, and several more of the same type are now being built at Crewe Works.

It will be observed that in the Webb type of compound locomotive the design is such that the sizes of the cylinders can be easily increased if necessary to obtain a still more powerful engine, provided, of course, a larger boiler is used, and there is no reason why even the *Dreadnought* should not be the forerunner of still more powerful compounds on the London and North-Western Railway when their use becomes a necessity. It is evident that the use of a third cylinder, with motion and gear, must entail a greater cost for repairs as well as a larger consumption of oil when at work, and that the type of engine does not easily lend itself to a speedy and economical rebuild of ordinary locomotives to the Webb compound type; the system, therefore, is one quite unique in its way, and unlike any of the earlier attempts at compounding locomotives.

Another successful design of compound locomotives is that due to Mr. T. W. Worsdell, the Locomotive Engineer of the North-Eastern Railway, on which railway a large number of compound locomotives are at work. The Worsdell compound is the outcome of many experiments both at home and abroad. There are two cylinders used, and to all appearances the locomotives are similar to the ordinary non-compound locomotive. These two cylinders are of different diameters, and the steam, after doing work in the smaller one, is exhausted into the steam-chest of the larger or low-pressure cylinder, where it is further reduced in pressure by expansion in the cylinder, and afterwards is exhausted. It will be observed that in the Webb system there are two high-pressure cylinders connected to the hind pair of wheels, with the crank-pins, of course, at right angles, and that the low-pressure piston receives no steam from the high-pressure cylinders until the engine has commenced to move. Thus, all the work of starting the train for the first few revolutions of the driving wheels has to be done by the high-pressure pistons, and these are always able to start, in whatever position the wheels may be, because they are in duplicate and have no dead point. In the Worsdell system this is not possible without some special appliance, and it is this particular appliance which constitutes the patented device in the engine which makes it the success it is. In any two cylindered compound engine with cranks at right angles, which is the usual practice, it is possible to easily observe that there are two positions from which the engine cannot start on the admission of steam, because the admission of steam to the low-pressure cylinder depends on the exhaust from the high-pressure cylinder, and the high-pressure piston may happen to be at exactly the end of its stroke, either at the front or the back end—known as being on the centre or dead points. As the Worsdell engine is constructed with two cylinders, as before stated, it will be interesting to know how the difficulty has been got over. When the high-pressure piston is at the end of its stroke, the low-pressure piston will be at the middle of its stroke, the cranks being at right angles; and if by any means steam could be admitted to the low-pressure cylinder without affecting the high-pressure piston, the engine would, of course, be able to turn round half a revolution, and so place the high-pressure piston immediately in a position to commence its stroke. The "intercepting valve," as it is called, is an arrangement by which the passage between the high- and low-pressure cylinders can be closed, and at the same time admits steam to the low-pressure cylinder when the high-pressure piston is on one or other of its dead points. This arrangement consists of a valve in the passage between the cylinders connected to a small piston in a cylinder placed in a suitable position. The steam supply is taken from the main steam-pipe, and regulated in its passage to the small cylinder by a valve worked from the foot-plate. If the engine refuses to start when the regulator is opened, the lever connected to the intercepting valve apparatus is pulled over. This admits steam behind the small piston, which immediately is forced forward and closes the intercepting valve, at the same time opening a port through which the steam is admitted to the low-pressure cylinder. This starts the engine, and the lever is returned to the running position by means of a spring. The rise of pressure in the passage between the cylinders, owing to the exhaust from the high-pressure cylinder, opens the intercepting valve, and compound working commences. This arrangement is very simple and trustworthy in practice. A large number of Worsdell compounds are now in use in India and elsewhere with admirable results. Where coal costs forty shillings and more per ton, it is very important that the most economical engine should be used.

On the Brighton Railway very economical results have long been obtained with the ordinary locomotives designed by the late Mr. Wm. Stroudley, and are due to the general excellence of design of boiler and engine, coupled with careful driving, induced by the coal premium. If locomotives were generally worked more by the reversing lever and less by the regulator, more economical results would be recorded; or, in other words, expansive working means economical working, which in the ordinary engine depends on the driver. In this manner, to work steam expansively in the non-compound locomotive, it is necessary for the driver to regulate the power of the engine by varying the quantity of steam used in the cylinders by means of an earlier or later cut-off, regulated by means of the reversing gear, the supply from the boiler not being checked in any way when running. On the other hand, the engine can be regulated by varying the steam supply at the regulator, the degree of expansion in this case being such as the driver chooses to generally use. Under the first conditions all the steam used is worked expansively, and under the latter the cylinders are choked with steam at one minute, and have an insufficient supply at the next. On the other hand, with the compound engine the steam must be expanded to a certain extent whether the driver likes it or not, and a result may be obtained with careless driving from the compound which would be passable when shown by a fairly well driven ordinary engine.

Mr. Drummond, the Locomotive Superintendent of the Caledonian Railway, has been making extensive experiments with steam-pressures varying from 150 to 200 lbs. per square inch, with identical engines doing practically the same work, the results of which will be given to the Institution of Civil Engineers. Without dealing with the practical difficulties involved in the use of such high pressures in non-compound locomotives, it will be highly interesting to know the results of these experiments. Whether the saving in fuel will equal or exceed the compound results obtained by Messrs. Webb and Worsdell is a moot point.

It has been observed that the saving of fuel due to a compound locomotive when working similar trains with the non-compound engine is due to the higher pressure used, and that when the pressure is reduced to the same level as that used in the non-compound engine the saving in fuel at once drops considerably, and the results give a little saving in favour of the compound. From this it is evident that to alter an ordinary engine to the compound system, without raising the working pressure, will be of little good, and not worth the cost.

The many statements made in order to prove the more economical working of the compound over the non-compound locomotive are misleading in the extreme, and as a fair comparison of the two types they are of no value. The compound locomotives have large boilers, ample heating surface, and all recent improvements, besides the all-important feature of a working pressure of 175 lbs. per square inch. This engine is compared with an ordinary non-compound locomotive having a smaller boiler, generally hard pressed for steam, because it has to haul its maximum load, with a working pressure of about 150 to 160 lbs. to the square inch. To put two such engines into competition is absurd, and therefore the results obtained by the compound locomotives in every-day working cannot fairly be compared with the non-compound engine's records.

For these and other reasons engineers are anxiously waiting to learn the results of Mr. Drummond's experiments, for then for the first time will it be possible to fairly compare the two systems.

It must not be imagined that because the compound and triple expansion marine engine is so successful in fuel economy, the compound locomotive is also likely to be so: the conditions of working are so totally different; for instance, the engines of an Atlantic liner work for seven or more days, doing practically the same amount of work the whole time, and since the work is constant the engines are designed to do that work in the most economical manner. With the locomotive, on the other hand, the work is never constant, and for that reason the steam supply is an ever-varying quantity, besides the constant stopping and reversing always going on when any shunting has to be done. These conditions are fatal to very economical working, and more especially when applied to a compound locomotive.

The compound principle is a sound one, but one not likely to be generally adopted, on account of extra complication. The present consumption of fuel by ordinary well-designed non-compound locomotives (take, for instance, the Brighton average consumption of 24·75 lbs. per mile for all their passenger engines) has not been beaten by the compound locomotive records; and until it can be demonstrated that a distinct economy is possible by their general use, they are not likely to increase largely in number.

N. J. L.

NEW ZOOLOGICAL PARK AT WASHINGTON.

By an Act of Congress passed on March 2 last year, an "appropriation" was made for the establishment of a Zoological Park in the district of Columbia "for the advancement of science and the instruction and recreation of the people." The control of the establishment was intrusted to a Commission composed of the Secretary of the Interior, the President of the Board of Commissioners of the District of Columbia, and the Secretary of the Smithsonian Institution.

Although the Commission was thus established only a year ago, the three Commissioners have already set to work, and, as we learn from their report, transmitted in January last to the Senate and House of Representatives have accomplished the first object of the constitution—namely, the purchase of the necessary land.

The site selected for the Zoological Park is about two miles from the centre of Washington. It contains an area of 166 acres, traversed by the stream called Rock Creek, and is stated to possess most attractive features which render it well adapted for the purpose.

There is already a Zoological Garden at Philadelphia in good working order, and there is a smaller establishment at New York, in the Central Park, under the charge of Mr. W. A. Conklin, who is well known to many naturalists on this side of the Atlantic. The new institution at the metropolis of the United States, to be inaugurated and carried on by the Central Government for the "recreation and instruction" of the American people, will evidently be on a much larger scale. It will also have the advantage of the unlimited support always accorded by the Americans to their great national undertakings. If the Commissioners are inclined to take advice from Europe—and we have no reason to suppose the contrary—we should recommend that, before planning and commencing the necessary buildings, they should visit the Gardens of the Zoological Society in London, and the principal institutions of a like nature on the Continent, and take advantage of the experience gained by previous workers in the same field. No amount of plans and estimates, which, we are told, they are now asking for from the older institutions, will give them the advantages to be derived from a personal examination of these establishments and a few weeks' study of the mode in which they are worked.

JAMES NASMYTH.

EVERYONE was sorry to hear of the death of Mr. James Nasmyth, the great engineer. His name is familiar to the entire English-speaking world, and there can be no doubt that he stands in the front rank of those who have advanced the material interests of mankind by the application of science to industrial methods.

So far as outward events were concerned, there was nothing very remarkable in his career. The real history of his life is the history of his inventions. He was born at Edinburgh on August 19, 1808, and was the youngest child of a family of eleven. His father was Alexander Nasmyth, who achieved considerable distinction as a painter. In a good summary of the facts of his life, printed in the *Times* of May 8, it is said that the boy gave very early evidence of a decided taste for mechanical pursuits. At school this taste was strengthened by intimacy with the son of an ironfounder, whose works young Nasmyth was never tired of visiting. He displayed so much aptitude for model-making that when he began to attend scientific classes at the University of Edinburgh he was able to pay his own fees by the sale of models of steam-engines, and other mechanical contrivances.

In 1829, Mr. Nasmyth came to London, and the two following years he spent in the service of Mr. Maudslay, the founder of the well-known firm of engineers. He then returned to Edinburgh, where he devoted himself for a short time to the construction of a set of engineering tools. With these tools, and a very small capital, he ventured to begin business on his own account in Manchester; and so many orders for work were received that new premises soon became necessary. He accordingly secured a plot of ground, 12 acres in extent, at Particroft, near Manchester; and this site he covered with the collection of workshops known as the Bridgewater Foundry. It was at this establishment that Mr. Nasmyth invented and perfected the mechanical tools with which his name is associated. The most important of them is the steam-hammer, the power and delicacy of which are universally known. It was invented in 1839, when he was still a young man. The *Times* says:—"The first idea of the hammer occurred to its inventor when he was asked by the Great Western Railway Company to construct a wrought-iron intermediate paddle shaft for a proposed ship called the *Great Britain*. Other firms had declined to undertake the construction of a shaft with a size and diameter never before attempted. The paddle shaft was never forged, as the screw was invented about this time. But meanwhile Nasmyth had invented a means of raising an enormous block of iron to a sufficient height and of regulating and directing its descent upon the anvil below."

Among Mr. Nasmyth's other inventions we may mention his "reversing direct-acting rolling mill."

In 1857, at the age of 48, he retired from business; and from that time he lived at Penshurst, where he found an outlet for his energies in the enthusiastic study of astronomy—a study which led to the publication of "The Moon considered as a Planet, a World, and a Satellite," written by him in conjunction with Dr. James Carpenter. Mr. Nasmyth wrote also "Remarks on Tools and Machinery," in Baker's "Elements of Mechanism" (1858). An autobiography, edited by Dr. Smiles, was published in 1883. He inherited to some extent his father's artistic faculty, and the exercise of his talent for drawing was a constant source of genuine pleasure.

Mr. Nasmyth used to say that he had never known what it was to be ill. For some time, however, his health was manifestly failing; and several weeks ago he came to town. He stayed at Bailey's Hotel, Gloucester Road; and there, in his eighty-second year, he died, on Wednesday, May 7.

NOTES.

MR. ALFRED GILBERT, A.R.A., has been commissioned to execute the Joule Memorial at Manchester.

PROF. W. K. SULLIVAN, President of the Cork Queen's College, and well known as a chemist, died on Monday at the College. He was 68 years of age, and had held the position of President since 1872, in succession to the late Sir Robert Kane.

IT is announced that Sir Frederick Mappin, M.P., has handed over to his co-trustees of the Sheffield Technical School £1000 for the purpose of founding two scholarships, each of the value of £15 per annum, in perpetuity.

THE Paris Academy of Sciences has offered a prize of 3000 francs for the best essay on the phenomena of fertilization in Phanerogams, especially in reference to the division and translation of the nucleus, and the relation between these phenomena and those which occur in the animal kingdom, to be sent in before June 1, 1891.

PROF. VON NORDENSKIÖLD lately announced to the Stockholm Academy of Sciences that a scientific expedition would start during the summer for Spitzbergen. Among the party will be his son, M. G. Nordenskiöld, and MM. Klinckowström and Bahaman. The expenses of the expedition will be defrayed by Baron Dickson and M. F. Beijer, the publisher.

THE ethnological collections made by Prof. Bastian during his journey through Russian Central Asia, have been brought to Berlin by the Professor's companion, Herr A. Dsirne. Prof. Bastian is at present at Madras.

DR. THORODDSEN, of Reikjavik, to whom the Linné Memorial Medal has been given by the Stockholm Academy of Sciences for his collection of fossil plants, has received 1200 kronen (£65) from Baron Dickson to enable him to investigate the Icelandic peninsula of Sneefieldness. Dr. Thoroddsen hopes soon to conclude his geological researches concerning this ancient Norse settlement.

Mr. T. G. Paterson, of Edinburgh, has sent to the *Daily News* the following information regarding what will be the most northerly telephone in Europe:—"My brother, Mr. Spence Paterson, H.M. Consul for Iceland, writes to me: 'It is proposed to put up a telephone line between Reikjavik and Havnefiord. The cost of apparatus and construction is reckoned under Kr. 30,000, and a small company is to raise the capital.'"

We learn from *Humboldt* that in connection with the tenth International Medical Congress, to be held this year in Berlin from August 4 to 9, there is to be an International Medico-Scientific Exhibition. The following kinds of objects will be exhibited: new or improved scientific instruments and apparatus for biological and especially medical purposes, including apparatus for photography and spectrum analysis so far as they are of service to medicine; new pharmaceutical and chemical stuffs and preparations; new or improved instruments for operative purposes of medicine, including electrotherapy; new plans and models of hospitals, convalescent homes, disinfection arrangements, baths, &c.; new arrangements for care of the sick, including means of transport, and baths for invalids; newest apparatus for hygienic purposes, &c. Communications (marked "Ausstellungsangelegenheit") should be sent to the office of the Congress, Dr. Lassar, Berlin, N.W., Karlstrasse 19.

The dinner given in honour of M. de Lacaze-Duthiers by the Club called *Scientia*, on April 30, seems to have been a great success. It took place in the Hôtel Continental. M. Charles Richet, who presided, delivered an eloquent speech on the achievements of the Club's guest—"that conqueror of the sea, and apostle of zoology"—calling attention especially to his services as the founder of the marine laboratories of Roscoff and Banyuls.

The *Kew Bulletin* for May opens with an interesting collection of facts relating to efforts which are being made to obtain commercial rubber from the "Abba" tree of West Africa. There are also sections on a mealy bug which has lately been very destructive to cultivated plants at Alexandria; on Mauritius hemp machines; on Siberian perennial flax; and on Liberian coffee.

The several Australian Governments have completed their arrangements with regard to the Mining Exhibition which is to be held this year at the Crystal Palace. According to the *Australian Mining Standard*, the best display will probably be made by New South Wales. Mr. Wilkinson, the Government Geologist, will visit England as the official representative of that colony; and the collections to which high honours were awarded at the New Zealand Exhibition will be sent to London.

The first number of "Records of the Australian Museum," edited by Dr. E. P. Ramsay, the Curator, has been issued. The editor explains that the rapid increase in the collections of the Museum, and the gradual acquisition of extensive series of new, or little known, forms from Australia, New Guinea, and the Pacific islands, have "forcibly brought under the notice of the trustees the necessity of officially publishing the investigations of their scientific staff." Accordingly the "Records" will appear as an occasional periodical. Among the contents of the first number are a report on a zoological collection from the Solomon Islands, by E. P. Ramsay and J. D. Ogilby; a re-description of an Australian skink, by the same writers; a report of a collecting trip to Mount Kosciusko, by R. Helms; general notes made during a visit to Mount Sassafras, Shoalhaven district, by R. Etheridge, Jun., and J. A. Thorpe; and a report on a collecting trip to North-Eastern Queensland during April to September 1889, by E. J. Cairn and R. Grant.

The Aëronautical Society of Great Britain will hold a meeting at the Society of Arts, on Friday, May 16, when a lecture will be delivered by Mr. Henry Middleton, of Slough, on "the fundamental principles of flight, and their application to the construction of flying machines." Mr. Edgar Stuart Bruce will read a short paper on electric balloon signalling, with details of some late experiments in Belgium.

An obituary notice of Theodor Kirsch has been issued as the fifth of the series of "Abhandlungen und Berichte" of the Dresden Zoological and Anthropological Museum, edited by Dr. A. B. Meyer. Herr Kirsch had charge of the entomological department of the Museum. The notice is accompanied by a portrait, and by a list of his writings.

The buildings of the Botanical Museum and Laboratory of the Michigan Agricultural College have been entirely destroyed by fire, and with them the whole of the Wheeler Herbarium, containing over 7000 species, the most complete collection of Michigan plants ever brought together.

The well-known botanical explorer Mr. C. C. Parry died at Davenport, Iowa, on February 20, from an illness following on an attack of influenza.

Dr. Tschirch, of Berlin, has been appointed Professor of Pharmacology in the University of Berne.

Dr. Istvánffy-Schaarschmidt has been appointed Curator of the botanical collections in the National Museum of Buda-Pesth.

Herr J. Bornmüller was engaged during April in a botanical investigation in Asia Minor. He began with the mountainous region in the neighbourhood of Amasia, and proceeded westwards into Galatia and Paphlagonia.

Two slight shocks of earthquake were felt at Sofia on May 10, at half-past 2 and at 3 o'clock in the afternoon. The seismic disturbances travelled in a vertical direction.

The Deutsche Seewarte has just published Part III. of "Ueberseeische meteorologische Beobachtungen," containing a valuable series of observations from distant stations, carefully compiled in the most desirable form. Full particulars are given about the positions of the stations, and the construction of the instruments.

We have received the Report of the Meteorological Service of the Dominion of Canada for the year 1886. It contains, as before, very clear tables of the daily, monthly, and quarterly means, for a large number of stations, and values of bright sunshine for 14 stations. The storm signal service seems to be much appreciated, and to be very successful; Mr. Carpmael states that, whenever a storm of any magnitude occurred, due warning was given to the shipping. The issue of daily weather forecasts has also been very successful—88·6 per cent. having been fully verified. The system of disseminating weather information, by attaching metal disks to the railway cars, has been perfected, and Mr. Carpmael states that these forecasts are as eagerly sought for by farmers and people resident in country districts as by the inhabitants of the towns where they are published. The Report also contains five coloured plates, showing the quarterly and annual distribution of rainfall in Ontario.

The daily and yearly variation, and the distribution, of wind-velocities in the Russian Empire have been fully investigated by Kiersnowski (*Repert. f. Meteor.*). The highest velocities (mean 6·3 metres per second) occur in the Baltic provinces. On the White Sea, on the Caspian, in the region of the North Russian lakes, and on the Steppe, the values are also high; in the forest region and the Caucasus they are low. Towards the interior of Asia the velocity decreases, and in Transbaikalia is the minimum (1·5 m. per second). Further east, towards the Pacific, the velocity increases. In the annual period, the maximum is pretty uniformly in winter, the minimum in summer. A maximum in spring, and a minimum in summer or autumn, are peculiar to the Caspian region, the Ural, and West Siberia, with Central Asia. In Eastern Siberia the minimum is in winter. The daily variation shows distinctly the connection with cloudiness. The greatest amplitude occurs in the brighter part of the year; in East Siberia in winter, and in the rest of the country in summer. In general the amplitude increases regularly with the clearness of the sky eastward, and on land it is greater than on the sea.

A STATISTICAL investigation of lightning-strokes in Central Germany, covering a period of 26 years, has been recently carried out by Herr Kastner (*Globus*). The number of cases has increased about 129 per cent., and last year (1889) it amounted to 1145. The author distinguishes four thunderstorm paths. The starting-points of all these are in hills, and in their course, the woodless districts and flat country, river-valleys and low meadow-ground about lakes, seem specially liable, while the wooded and hilly parts generally escape. The hottest months (June, and especially July) and the hottest hours of the day, or those immediately following them (3 to 4 p.m.), show the most lightning strokes.

IN *Le Globe* for March, M. E. Chaix has an article on the general circulation of the ocean. He enters into the various means adopted for determining ocean currents, and the history of the various theories from the earliest times, and gives a brief summary of those which are now generally adopted. The author adopts the opinion expressed by Humboldt, that several causes must be sought for, and that they cannot be explained by any single one. His conclusions are: (1) that differences of density, especially those caused by temperature, induce a slow progression of the water at a depth towards the equator, but that their action is apparently nothing at the surface; (2) that the prevailing winds cause sensible currents at the surface, and these movements in time penetrate to a certain depth, but that their agency does not explain everything; (3) every motion, whether on the surface or at a depth, causes a compensating movement, either slow or rapid. These movements play the second part in the superficial circulation, and explain generally what cannot be attributed to the direct action of the wind; therefore they afford a key to a number of apparent anomalies.

IN the last report of the Central Park Menagerie, New York, it is noted that the principal cause of death among the animals in 1889 was congestion of the lungs. Among the most valuable specimens lost by this disease were—a lioness, purchased March 4, 1886; two pumas, one received in 1883, the other in 1885; one llama and one emu, both purchased in 1888; one sea-eagle and one migratory pigeon, the former of which had been in the collection for eighteen, the latter for thirteen, years. The death of a young hippopotamus, four days after birth, was also attributed to congestion of the lungs. In describing what happened in the case of this interesting creature, Mr. W. A. Conklin, the Director, points out that the Zoological Gardens of Europe have been particularly unfortunate in regard to the first-born of the hippopotamus. "The first two born in the London Garden lived two and four days respectively. The first two born in the Jardin des Plantes, Paris, were killed by their parents shortly after birth. In the Amsterdam Garden the first two died from the neglect of their parents, and in St. Petersburg Garden the first three died from the same cause."

IN a note in the current number of the *American Naturalist*, Mr. F. F. Payne, of Toronto, records an interesting fact which often came under his notice during a prolonged stay at Hudson's Strait. "Here," he says, "the Eskimo might often be seen lying at full length at the edge of an ice-floe, and, although no seals could be seen, they persistently whistled in a low note similar to that often used in calling tame pigeons, or, if words can express my meaning, like a plaintive phe-ew, few-few, the first note being prolonged at least three seconds. If there were any seals within hearing distance they were invariably attracted to the spot, and it was amusing to see them lifting themselves as high as possible out of the water, and slowly shaking their heads, as though highly delighted with the music. Here they would remain for some time, until one perhaps more venturesome than the rest, would come within striking distance of the Eskimo, who, starting to his feet with gun or harpoon, would often change the seal's tune of joy to one of sorrow, the others making off as fast as possible. The whistling had to be continuous, and was more effective if performed by another Eskimo a short distance back from the one lying motionless at the edge of the ice. I may add that the experiment was often tried by myself with the same result."

A NEW instalment of the "Palæontologia Indica" has been published. It forms the first part of vol. iv. of the series dealing with "salt-range fossils," by Dr. William Waagen. This volume is being written in fulfilment of a promise made by Dr. Waagen when, in 1879, he began his publications on the different rock-groups of the salt-range and the fossils contained therein. He then undertook to collect in a special volume "all the geological conclusions that may be drawn from the detailed study of the different faunæ, and to give at the same time geological details as to the occurrence of the single forms."

THE Straits Branch of the Royal Asiatic Society, has published the twentieth number of its Journal. It contains a report on the destruction of coco-nut palms by beetles, by H. N. Ridley; British Borneo—sketches of Brunai, Sarawak, Labuan, and North Borneo, by W. H. Treacher; notes on names of places in the island of Singapore and its vicinity, by H. T. Haughton; journal of a trip to Pahang, &c., by W. Davison; and a list of the birds of the Bornean group of islands, by A. H. Everett. A map of Borneo, and a map of Palawan and adjacent islands, are given. The former shows roughly the distribution of highlands and lowlands in Borneo, and the localities at which collections of birds have been made are indicated.

CLOSE to the Hungarian village of Toszeg, on low ground often flooded by the Theiss, are the remains of a prehistoric settlement, which have been recently described by a Scandinavian man of science, M. Undset. While in Upper Italy a sort of basin seems often to have been made with an earth-wall, and dwellings built in this on a pile-supported platform; the buildings near Tozseg have been similarly raised in two long parallel trenches. The hollow space under the platform served as a place for refuse of all sorts, and it must often have held stagnant water. When it got full, the settlement appears to have been burnt down, and a new set of buildings raised on new and higher piles. Among the remains are bones of cattle, stags, goats, swine, &c., vessels made of horn, stone, baked clay, a few bronze articles (needles, knives), polished stone hammers, wedges, chisels, tooth-ornaments, &c. The settlers seem to have practised agriculture, hunting, and fishing. Discussing this "find," M. Undset has some remarks on the relations of the prehistoric civilization of Hungary to that of Upper Italy and other European regions. In Northern Italy the bronze period proper appears to have corresponded pretty nearly with the *terramare* settlements; but in Hungary it was much longer, and was in great part contemporaneous with the iron period in Italy. When the bronze period began in Hungary is very doubtful, but M. Undset considers it to have been not later than in Upper Italy. It is highly probable that the very early migration of Italians into the Apennine peninsula, and the migrations into the Balkan peninsula culminating in that of the Dorians, came from the middle or lower Danube valley. Hence the importance of prehistoric remains in Hungary for a knowledge of prehistoric events in Central Europe.

Another important paper is contributed by M. Moissan to the current number of the *Comptes rendus* upon carbon tetrafluoride, CF_4. Five modes of preparing the gas are described, together with several new properties which have been investigated since the publication of the preliminary notice a few weeks ago. When gaseous fluorine is allowed to enter a platinum tube filled with marsh gas, CH_4, a violent combination, accompanied by incandescence, takes place, carbon being deposited and a mixture of various fluorides including carbon tetrafluoride formed. Fluorine also reacts somewhat violently with chloroform, $CHCl_3$. When the free element is led into cooled chloroform it is largely absorbed, carbon tetrafluoride being again produced, and for the most part remaining dissolved in the excess of chloroform. If the fluorine is heated to 100° before passing into the chloroform incandescence occurs, a flame appears at the exit opening of the platinum apparatus, carbon is again deposited, and the tetrafluoride largely found in the gaseous product. Fluorine also expels chlorine from tetrachloride of carbon, CCl_4, for if it is led into a quantity of the tetrachloride contained in a gently-warmed platinum flask, the issuing gas is found to be a mixture of free chlorine and carbon tetrafluoride. A large proportion of the latter gas remains dissolved in the excess of carbon tetrachloride, and may be readily obtained fairly pure by gently boiling the residual liquid in a glass vessel and collecting the gas over mercury. As described in our notice of the preliminary paper the lighter varieties of amorphous carbon, such as wood charcoal and lamp black, take fire in a stream of fluorine and continue burning as long as combination occurs, the product consisting of several gaseous fluorides, of which the tetrachloride is present in greatest proportion. The method, however, by which carbon tetrafluoride can be prepared most conveniently and in the purest form is as follows. A quantity of silver fluoride, AgF, is placed in a brass U-tube fitted with two side tubes. Through one of these latter a stream of vapour of carbon tetrachloride is driven; the other serves as exit tube for the products of the reaction. The apparatus is first filled with carbon tetrachloride vapour, the portion containing the fluoride of silver is then heated to 195°–220° C. and a steady stream of the tetrachloride maintained as long as gas is evolved at the mercury trough. It is advisable to add to the apparatus a small metallic spiral tube which can be cooled to − 23° in order to condense any escaping vapour of the tetrachloride, and which is so arranged that the condensed liquid can be returned to the vessel in which the tetrachloride is being vapourized and so passed again into the reaction tube. The last traces of carbon tetrachloride may be removed by allowing the gas to stand twenty-four hours over mercury in contact with a few scraps of caoutchouc. In order to free it from admixed heavier fluorides advantage is taken of the fact that large quantities of the tetrafluoride are absorbed by absolute alcohol. On agitation with a little absolute alcohol, therefore, the tetrafluoride is absorbed, and may be again liberated either by addition of water, in which the gas is scarcely perceptibly soluble, or by ebullition. If the latter plan is adopted the alcohol vapour may be removed by washing through sulphuric acid. It is important to use a metallic reaction tube in the preparation, inasmuch as glass is rapidly attacked by carbon tetrafluoride, the product of the reaction in a glass vessel consisting of a mixture of silicon and carbon tetrafluorides, carbon dioxide, and a heavier fluoride of carbon, $CF_4 + SiO_2 = CO_2 + SiF_4$. Carbon tetrafluoride liquefies at − 15° at the ordinary atmospheric pressure, and under a pressure of four atmospheres at 20°. When passed over heated sodium it is completely absorbed, carbon being deposited and sodium fluoride formed. Aqueous potash appears to be without action upon it, but alcoholic potash slowly absorbs it with formation of carbonate and fluoride of potassium.

The additions to the Zoological Society's Gardens during the past week include a Blossom-headed Parrakeet (*Palæornis cyanocephalus* ♂), two Red-eared Bulbuls (*Pycnonotus jocosus*) two Red-vented Bulbuls (*Pycnonotus hæmorrhous*), a Large Hill-Mynah (*Gracula intermedia*) from India, a Red-sided Eclectus (*Eclectus pectoralis* ♀) from New Guinea; two King Parrakeets (*Aprosmictus scapulatus* ♂ ♀), a Pennant's Parrakeet (*Platycercus pennanti*), a Chestnut-eared Finch (*Amadina castanotis* ♀) from Australia, a Ceylonese Hanging Parrakeet (*Loriculus asiaticus*) from Ceylon, a Mealy Amazon (*Chrysotis farinosa*), two Yellow-shouldered Amazons (*Chrysotis ochroptera*), a Blue-fronted Amazon (*Chrysotis æstiva*), a Red-crested Cardinal (*Paroaria cucullata*) from South America, a Levaillant's Amazon (*Chrysotis levaillanti*) from Mexico, two Panama Amazons (*Chrysotis panamensis*) from Panama, a Yellow-vented Bulbul (*Pycnonotus crocorrhous*) from Sumatra, two Orange-cheeked Waxbills (*Estrelda melpoda*), two Red-bellied Waxbills (*Estrelda rubriventris*), a Cut-throat Finch (*Amadina fasciata* ♂), a Shining Weaver Bird (*Hypochera nitens*), an Olive Weaver Bird (*Hyphantornis olivaceus*) from South Africa, a Crimson-crowned Weaver Bird (*Euplectes flammiceps*), a Grenadier Weaver Bird (*Euplectes oryx*), a Green Glossy Starling (*Lamprocolius chalybeus*) from West Africa, two Madagascar Weaver Birds (*Foudia madagascariensis* ♂ ♀) from Madagascar, a Red-headed Cardinal (*Paroaria larvata*) from Brazil, a Cardinal Grosbeak (*Cardinalis virginianus* ♀) from North America, presented by Dr. Seton; a Red-eared Bulbul (*Pycnonotus jocosus*), a Red-vented Bulbul (*Pycnonotus hæmorrhous*) from India, presented by Lieut.-General Sir H. B. Lumsden, K.C.S.I.; a Ring-necked Parrakeet (*Palæornis torquatus* ♀) from India, presented by Mrs. O. Harvey; a Redwing (*Turdus iliacus*), British, presented by Mr. J. Newton Hayley; a Common Viper (*Vipera berus*), a Slowworm (*Anguis fragilis*), British, presented by Dr. W. K. Sibley; three Green Tree Frogs (*Hyla arborea*) from France, presented by Mrs. Humphreys; two Hartebeests (*Alcelaphus caama* ♂ ♀) from South Africa, a Bennett's Wallaby (*Halmaturus bennetti* ♂) from Tasmania, a Black Wallaby (*Halmaturus walabatus* ♀), two Brush-tailed Kangaroos (*Petrogale penicillata* ♂ ♂) from New South Wales, four Common Quails (*Coturnix communis*), European, deposited; two Demoiselle Cranes (*Grus virgo*) from North Africa, purchased; a Japanese Deer (*Cervus sika* ♂), a Hog Deer (*Cervus porcinus* ♀), ten Cuming's Octodons (*Octodon cumingi*), born in the Gardens.

OUR ASTRONOMICAL COLUMN.

Objects for the Spectroscope.

Sidereal Time at Greenwich at 10 p.m. on May 15 = 13h. 34m. 18s.

Name.	Mag.	Colour.	R.A. 1890.	Decl. 1890.
			h. m. s.	° ′
(1) Uranus, May 15 ...	—	Bluish-green.	13 27 40	− 8 33
,, ,, 29 ...	—	—	13 26 4	− 8 24
(2) G.C. 3615	—	—	13 32 4	+ 9 27
(3) 163 Schj.	7	Reddish-yellow.	13 48 29	+40 47
(4) 84 Virginis	6	Yellow.	13 37 30	+ 4 6
(5) ζ Virginis	3	White.	13 29 12	− 0 2
(6) T Ursæ Maj.	Var.	Red-yellow.	12 31 23	+60 6

Remarks.

(1) A question of great interest was raised last year by spectroscopic observations of the planet Uranus. As is well known, the spectra of Uranus and Neptune differ very widely from those of the other planets. They show no solar lines in the visible spectrum even when telescopes of very large apertures are em-

ployed; but in place of them there are several broad dark bands to which no origins have yet been assigned. Secchi first observed the spectrum in 1869, and he pointed out that, if the luminosity of the planet be due to solar light, it must undergo great modifications in the atmosphere of the planet. Vogel and Huggins re-observed the spectrum and mapped it in considerable detail, Vogel giving the positions of no less than twelve bands. The five principal bands have the following positions:—

618. Darkest part of a broad band, ill-defined towards the red.
596. Middle of a faint narrow band.
573·8. Darkest part of a broad band.
542·5. Middle of darkest band in spectrum.
486·1. Middle of a dark band.

It has not yet been possible to explain any of the dark bands by comparisons with known absorption spectra; one band is certainly coincident with the F line of the solar spectrum, but it is much too broad to be due to reflected sunlight. Prof. Lockyer gave his attention to the spectrum last year, and thought it possible that many of the apparent dark bands were simply contrast appearances due to the presence of radiation flutings. At his suggestion I examined the spectrum, and came to the conclusion that he was right. I afterwards made observations, in conjunction with Mr. Taylor, with Mr. Common's 5-foot reflector. A full account of the results is given in Mr. Taylor's paper on the subject (*Monthly Notices*, vol. xlix. p. 405). We decided in favour of bright flutings, and Mr. Taylor afterwards mapped them very carefully. The brightest fluting is near *b*, and it is remarkable that Secchi noted this brightening in his light-curve of the spectrum. Mr. Espin has since observed that the blue end of the spectrum is broken up into bright bands and dull shadings. If the apparent bright flutings are not contrast effects, as has been suggested, the planet must be to a great extent self-luminous. Dr. Huggins has since photographed the violet end of the spectrum, and finds nothing but solar lines—a fact which is very difficult to explain, when the remarkable character of the visible spectrum is considered.

It is highly important that further observations, by as many different observers as possible, should be made. The apparent diameter of the planet is so small that a Maclean spectroscope shows the bands very well, but the brightnesses are best seen when the spectrum is narrow, as is the case with bright-line stars.

(2) This nebula is thus described in the General Catalogue: "Bright; large; extended in a direction 150°; pretty suddenly brighter in the middle to a resolvable nucleus." The apparent size of the nebula, according to the Harvard College observations, is 3′ × 1′. The spectrum has not been recorded.

(3) This star is one of considerable interest. Dunér says: "It appears to have a narrow band in the red, and a wide one in the green. Perhaps III.*a* (Group II.), but by no means III.*b* (Group VI.)." It has been suggested, from a discussion of the other members of the group, that the star is a representative of the very earliest stage of Group II., but further details are necessary before it can be said with certainty. The condition here should be almost cometary, and hence, in further observations, the bright flutings of carbon should be particularly looked for. So far, this is the only observed star which may possibly belong to the first species of the group.

(4 and 5) These stars are included in Vogel's spectroscopic catalogue. The first is stated to be of the solar type, and the second of Group IV. The usual observations are required in each case.

(6) This variable will reach a maximum about May 20. The range is from 6·4–8·5 to 13 in 255·6 days. The spectrum is one of Group II. (Dunér), the bands being wide, but not very dark. The usual observations for bright lines and other variations are suggested.

A. FOWLER.

CHANGES IN THE MAGNITUDES OF STARS.—At the April meeting of the Royal Astronomical Society Mr. Isaac Roberts presented a photograph of stars in the regions of Tycho Brahe's Nova taken on January 12, with an exposure of 2 hours 55 minutes. D'Arrest charted the stars in the region of the Nova in 1864 down to the 16th magnitude, and this chart has been used by Mr. Roberts to compare with his photograph. He finds no appearance of either a nebula or of a star on the photograph in or about the position indicated by D'Arrest, but a comparison of the chart and catalogue with the photograph shows that changes have taken place both in the positions and magnitudes of several of the stars since 1864. The changes particularized are important when it is considered that they apply to less than half a degree in right ascension, and one degree in declination. That six of the stars shown on D'Arrest's chart and not shown on the photograph, are absent on the latter on account of some physical change having taken place in the stars, receives confirmation from the fact that the photograph shows more than 400 stars on a sky space where D'Arrest has charted only 212 stars.

A MECHANICAL THEORY OF THE SOLAR CORONA.—Prof. Schaeberle of the Lick Observatory, has propounded an entirely novel theory of the solar corona, a discussion of which will appear in the report of the eclipse of December 22, 1889. His investigations seem to prove that the corona is caused by light emitted and reflected from streams of matter ejected from the sun by forces which in general act along lines normal to the surface. These forces are most active near the centre of each sun-spot zone. Owing to the change of the position of the observer with reference to the plane of the sun's equator, the perspective overlapping and interlacing of the two sets of streamers at these zones causes the observed apparent change in the type of the corona. To roughly test the theory Prof. Schaeberle has stuck a lot of needles in a ball to represent the streams of matter, placed the model in a beam of parallel rays, and allowed its shadow to fall upon a screen, the result being that an infinite variety of forms similar to the coronal structure can be reproduced by simply revolving the model. It remains to be proved whether a comparison of the forms that are seen according as the observer is above, below, or in the plane of the sun's equator, agree with those that should be seen on this theory.

THE IRON AND STEEL INSTITUTE.

THE annual meeting of the Iron and Steel Institute was held on Wednesday and Thursday of last week, in the theatre of the Institution of Civil Engineers, the President, Sir James Kitson, occupying the chair. There was a fair programme of ten papers, and another was added after the list had been printed. The following were the papers read:—

On a new form of Siemens furnace, arranged to recover waste gases as well as waste heat, by Mr. John Head, London, and M. P. Pouff, Nevers.

Calculations concerning the possibility of regenerating the gas in the new Siemens furnace, by Prof. Åkerman, Stockholm.

On the critical points of iron and steel, by M. F. Osmond, Paris.

On the carburization of iron by the diamond, by Prof. W. C. Roberts-Austen, London.

The changes in iron produced by thermal treatment, by Dr. E. J. Ball, London.

On the Robert-Bessemer steel process, by Mr. F. Lynwood Garrison, Philadelphia.

Aluminium in carburetted iron, by Mr. W. J. Keep, Detroit.

On certain chemical phenomena in the manufacture of steel, by Mr. W. Galbraith, Chesterfield.

The estimation of phosphorus in the basic Siemens steel bath, by Mr. W. Galbraith, Chesterfield.

On the Rollet process for producing purified castings, by Mr. A. Rollet, St. Etienne.

The first six of these papers were read and discussed at the first day's sitting (Wednesday); and the remaining four were disposed of before lunch-time on Thursday. It is seldom that we have seen papers "rattled off"—the phrase most aptly describes the procedure—in so rapid a manner. The members who were present may certainly be congratulated upon having got through a great many papers in a very short space of time; but it is a question whether there would not have been a gain to knowledge had the discussions been of a somewhat more deliberate nature.

In addition to the above papers there was on the agenda a memoir by Sir Henry Roscoe, on the action of aluminium on iron and steel. This, however, was not forthcoming; a fact which is to be regretted, as also is the cause which led to it, the subject being one of considerable scientific and industrial importance at the present time, when the production of aluminium is being so much cheapened, and such great things are promised by those who advocate its use in the metallurgy of iron and steel. Fortunately Mr. Keep's paper was forthcoming, and this elicited a brief but useful discussion, in the course of which Mr. James Riley, of the Steel Company of

Scotland, and others, gave the valuable information drawn from the practical experience they had gained in the alloying of iron with aluminium on a large scale. We will, however, take the papers so far as space will permit, in the order in which they were read.

Mr. Head's paper was read at the Paris meeting of the Institute, held last autumn, but was not then discussed. The author first points out that, in 1817, the Rev. Robert Stirling and his brother James Stirling applied the regenerative principle to air-engines, and that both they and J. Slater, in 1837, and R. Laming in 1847, foresaw the possibility of its application to metallurgical operations. The new Siemens furnace, which was the subject of the paper, was described and illustrated by wall-diagrams, without reproducing which it is not possible to make the arrangement clear. The chief point is that the waste gases are reconverted into combustible gases by being taken partly through an air-regenerator, and partly under the grate of the producer, so that they distil the hydrocarbons from the coal; in fact, the gas-producer utilizes the heat formerly deposited in the air regenerators. A steam jet is used for starting the action. This new form of regenerative gas-furnace has been applied to the heating and welding of iron. It is to be used for puddling, and for copper and steel melting. It is claimed that it effects a saving in fuel of about two-thirds the weight, a reduction in the weight of iron equal to 5 per cent., and a saving in labour and repairs. Figures were quoted supporting these claims.

Prof. Åkerman's paper was a discussion on the theory of combustion raised by the process. The subject is one of considerable interest, and is well put forward by the author. His conclusions are of considerable interest from a philosophical point of view, but are to a great extent robbed of their importance from an operative standpoint, from the uncertainty existing upon the specific heat of gases at high temperatures; which is only one more fact emphasizing the want of a proved and trustworthy pyrometer.

A brief discussion followed, in which Sir Lowthian Bell took the chief part.

M. Osmond's paper was one of those which must be the despair of the writers of brief notices such as this. It consisted of 33 pages, giving results of experiments made to ascertain the effects of varying temperature on different alloys of iron. In the presence of such a mass of matter as this we can only refer our readers to the Transactions of the Institute, where they will find the facts detailed and the diagrams by which they were illustrated fully set forth. We will content ourselves with simply stating that the "critical points" are points of arrestation in the cooling of iron and steel. It is interesting to notice the effect of various alloys on this phenomenon. Perhaps, to those members who were not previously acquainted with the instrument, the description of the thermo-electric pyrometer of Le Chatelier was not the least interesting part of the paper. A valuable bibliography is given in an appendix. In the discussion Mr. Wrightson gave some particulars of experiments he had made to ascertain the change of volume of iron at different temperatures, which he did by plunging an iron ball into liquid iron. The ball would at first sink, but rise as it acquired heat, and indications were thus obtained, which appeared to correspond with the "critical points" of the author. Mr. Hadfield also made some interesting remarks on the state of carbon in iron.

Prof. Roberts-Austen's paper followed. The Professor is not, of course, the first to carburize iron by means of the diamond; indeed, it has been a somewhat favourite experiment, with which the name of more than one eminent physicist in times past has been associated. But Prof. Roberts-Austen is, we believe, the first to perform the operation *in vacuo*, the iron itself being previously heated *in vacuo* to deprive it of its occluded gas. The author of the paper refers to the experiments of Hempel, who heated diamond and iron in an atmosphere of nitrogen perfectly free from oxygen, and points out that his, the author's, experiments are interesting from the assertions made by a certain school of chemists that no two elements can react on each other unless a third be present. "It would appear, however," Prof. Roberts-Austen says, "that a mere 'trace' of such additional element is sufficient to insure combination; for, in the experiments I have described, carbon and iron in their purest obtainable forms were used, and the only additional matter which could have been present was the trace of occluded gas which the iron may possibly have retained." The author is satisfied that combination does not take place until a full red heat is reached.

Dr. Ball's paper dealt with the changes in the magnetic capacity and tensile strength of steel which occur at definite temperatures, and showed how these changes may be made evident when the metal is rapidly cooled in water or in oil. Two samples of steel, one basic Bessemer and the other acid open-hearth, were submitted. Analysis showed that all the elements for which tests are usually made were almost identical, except manganese, of which the percentages were 0·284 for Bessemer, and 0·546 for open-hearth. The results are plotted on three sets of diagrams, one diagram in each set showing the results obtained with tests hardened, from varying temperatures, in water, in oil, and annealed respectively; the sets of diagrams refer to unstrained bars, the same bars strained to the yield point, and the same bars strained almost to the breaking point. These last two papers were discussed together.

Mr. Garrison's paper was read at the Paris meeting of September last, but not then discussed. It describes an elliptical converter in which the *tuyères* are so arranged that they blow air at the surface of the metal in a manner which causes a rotary motion of the bath, combustion taking place at the surface. The device is not altogether new, as surface blowing was suggested, and, indeed, patented, by Sir Henry Bessemer in the early days of the Bessemer process.

Mr. Keep's paper on aluminium, in carburetted iron, was the first taken on the Thursday morning. In it the results of certain tests were given, the details being set forth in graphic form. The points noted were strength to resist both weight and impact, deflection, set, elasticity for stresses applied, shrinkage for cast metals, hardness, and rigidity. This paper must be read with others that have been brought forward by the author, whose work in connection with the subject is well known. As a general result the tests go to show that the effect of a proper quantity of aluminium on commercially pure iron is to produce a material which is soft, easily bent, and flows readily. Aluminium diminishes deflection by decreasing the set and elasticity. Rigidity is also increased, the grain is closer and more uniform; in short, the author claims that by aluminium the metal is improved in every way when considered as a structural material.

In the discussion which followed the reading of the paper, Mr. James Riley, the manager of the Steel Company of Scotland, said that he had tried the effect of aluminium in steel on a large scale, but had been disappointed in the results. There were advantages, but these were so slight as to be insufficient to pay for the additional expense of one to two pounds a ton. Fluidity was gained, tensile strength was very slightly increased, the elastic limit was raised considerably, and ductility was increased. If aluminium could be reduced sufficiently in price it would be good to use it, but Mr. Riley had not considered the game worth the candle, and had ceased to use it a year ago. He had, however, been induced lately, by being told of the wonderful results obtained, to make further experiments, but his present frame of mind was not to use aluminium excepting for very fine thin castings. Mr. Spencer, of Newburn, another large steelmaker who has achieved great success in certain special branches of manufacture, endorsed what Mr. Riley had said. Mr. Allen pointed out that there might be traces of aluminium in pig-iron without its being discovered, as chemists only tried, as a rule, for the usual alloys. It was also important to remember that although aluminium might be put into the pot it did not necessarily appear in the product, as it might be removed by chemical reaction during the process. The latter point was supported by Dr. E. Riley and Mr. Stead.

Mr. Galbraith's two contributions were next read and discussed, but do not call for any special mention. Finally, Mr. A. Rollet's paper was read, in which his process of obtaining purified metal for castings was described. The process was illustrated by diagrams, and may be said briefly to consist of eliminating from pig-iron, to be used for the manufacture of particular qualities of steel, sulphur, phosphorus, and silicon. The pig is placed in a special cupola, and is maintained at a very high temperature under a double action, slightly reducing and slightly oxidizing, in the presence of a slag obtained by admixtures of limestone and lime, iron ores, and fluor-spar. By the arrangement of the cupola the metal is separated from the slag as soon as they are removed from the action of the blast in tapping. In this way the phosphorus already eliminated is prevented from going back into the metal, and too great a recarburization is also avoided. The elimination of sulphur is complete up to 99 per cent. and even more; that of phosphorus amounts to 80 or 85 per cent., or even 90 per cent. and more.

A short discussion followed the reading of the paper. The only important point brought forward, however, was a statement by Mr. Hugh Bell that, at Clarence, they had been carrying on a process almost identical with that described by the author. Had he, the speaker, been aware that the plan was in use elsewhere, and had he known a paper was to be read on the subject, he would have come provided with certain figures bearing on the matter.

The meeting then broke up after the usual votes of thanks had been duly passed.

The autumn meeting of the Institute is this year to be held in America. The meeting will be held in New York, and we hear rumours of vast preparations that are being made by the hospitable metallurgists and engineers of the United States to welcome their British *confrères*. Members are left to make their own way to New York, but upon landing they become the guests of the American Institute of Mining Engineers. From an outline programme we have seen, it would appear that the only limit to the excursion will be the time at the disposal of members, which, those who know American hospitality best will agree, is sure to be exhausted long before the good-nature of their hosts.

We should have stated before that Mr. W. D. Allen, of Sheffield, this year has been awarded the Bessemer Gold Medal. Mr. Allen was associated with Sir Henry Bessemer in the manufacture of Bessemer steel from the very first. Indeed, he may be said to have been present at the birth of the invention, and was fully acquainted with the whole process before a single patent was taken out.

A MONUMENT TO A FAMOUS JAPANESE CARTOGRAPHER AND SURVEYOR.

THE *Japan Weekly Mail* contains a report of the unveiling of a monument in Tokio on December 14, 1889, to the memory of Ino Chukei, a Japanese cartographer and surveyor of the early part of the present century. The ceremony was performed by Prince Kitashirakawa, President of the Tokio Geographical Society. The name of Ino Chukei was first made familiar to the Western world by Dr. Naumann, the organizer, and for many years the head of the Geological Survey Bureau of Japan. More lately, Dr. Knott wrote two short biographies of Ino, the one published in the Transactions of the Asiatic Society of Japan (vol. xvi., 1888), and the other as an appendix to the memoir on the recent Magnetic Survey of Japan, published in the Journal of the College of Science, Imperial University (vol. xi., 1888). Ino was by profession originally a brewer, and did not begin his scientific life till he was past fifty. The story of the enthusiastic septuagenarian travelling over the length and breadth of Japan with his quadrant, his azimuth circle, his compass, and his clock is almost a romance. His latitude measurements are still of importance to the cartographer, and his map of Japan has formed the basis of every map since constructed. He finished his grand survey in 1818, after 17 years of travelling and observing. And now, nearly seventy years after his death, a lasting memorial has been raised at Shiba, in Tokio. The ceremony of unveiling the monument began at 2 p.m. on December 14, in the presence of a large company. Amongst those present were Prince Kitashirakawa, Viscount Sano, Viscount Enomoto, Admirals Akamatsu, Nakamuta, and Yanagi, Mr. Hanabusa (Councillor), Mr. Arai, Director of the Meteorological Office, Mr. Watanabe, President of the Imperial University, many of the University Professors, and others. The Chinese Representative, the German Minister, M. Dautremer, of the French Legation, and Profs. Burton, Divers, and Knott, may be named as the diplomatic and scientific representatives of foreign nations. The Naval Band was in attendance, and filled the intervals between the different parts of the celebration with selections of music. Four Shinto priests first went through a religious ceremony, which consisted chiefly of purificatory rites, and an invocation to the spirit of Ino. Mr. Watanabe then read a report, giving a history of the movement, which originated seven years ago with the members of the Tokio Geographical Society, and culminated in the ceremony of the day. The original desire had been to put up the monument on the site of the spot where Ino made the first observations in his grand survey—that is, the point through which the zero meridian was taken. This was at Shinagawa. But it had been found more convenient to raise the memorial at Shiba, within sight of this first station. The monument, designed by Prof. Tatsuna, of the Imperial University, and cast in bronze at the Kawaguchi Foundry, had cost nearly 3800 dollars. The whole of the expenses had amounted to about 4000 dollars, which had been met by voluntary subscriptions from the members of the Geographical Society and many others who desired to contribute their mite. The monument, a graceful obelisk of a dull green tint, was unveiled by Prince Kitashirakawa, a translation of whose speech runs thus:—"What an achievement in cartography was that of learned Ino Chukei! During the eras of *Kansei* and *Bunsei* (1790 to 1820), when Japan, at peace within her own borders, isolated from intercourse with the outer world, divided into a number of mutually-secluded fiefs, and, undisturbed by the cares of coast defence, was content with her own littleness, Ino, his fiftieth year already passed, commenced the study of geodesy, and, equipped with instruments of his own manufacture, devoted eighteen years of toil and suffering to the survey of the empire, bequeathing to posterity the memory of a truly great work. From the point of view of strategical advantage, from the point of view of the progress of civilization, from a domestic as well as from a foreign point of view, Ino undoubtedly was a credit to his country. His name is on the lips of the whole nation. The Emperor himself has bestowed posthumous rank on him and presents on his descendants. Japanese and foreigners have contributed to erect to his memory a monument of dimensions unparalleled in Japan. And it is a privilege conferred on me in this enlightened era that, as President of the Tokio Geographical Society, I am permitted to speak of his achievements and to unveil his monument. I rejoice greatly to take part in this imposing ceremony, and I am persuaded that the spirit of Ino in heaven will share the satisfaction which his posterity must feel on such an occasion. Reverentially, on behalf of this Society, I unveil the monument. May the fame of the illustrious dead grow with the growth of our country's civilization."

After some minutes' interval, Viscount Sano advanced to the foot of the steps that lead up to the pedestal, and introduced to the audience the great-great-grandson of Ino, who bowed and expressed the gratitude of the family for the honour done to their ancestor. Viscount Sano then gave a short biographical sketch of Ino, and an account of his great labours, for which he had earned the never-dying gratitude of his countrymen. This ended the ceremony. Later on, in the rooms of the Geographical Society, a select party assembled to inspect the rude instruments with which Ino carried out his observations. The obelisk is very graceful in form, and beautiful in its setting. As already mentioned, the colour is pleasing, and the inscription is artistic as only an ideographic inscription can be. The monument is 34 feet high, the obelisk itself being 27 feet. A flight of steps ascends to a square platform of masonry in the centre of which the pedestal rests. A railing, the bars of which are curved and puckered up so as to represent sea and clouds according to a common Japanese convention, runs round the outer edge of the platform and down the sides of the steps, allowing free ingress and egress to the pedestal and obelisk. The obelisk faces nearly south, and in its back is a door by which access can be gained to the interior. It is intended to place inside the instruments already spoken of, which were used in Ino's survey.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, May 1.—"The Development of the Sympathetic Nervous System in Mammals." By A. M. Paterson, M.D.

At the present time two opposite views exist among embryologists regarding the development of the sympathetic system. In both, the segmental formation of the sympathetic cord is upheld. According to the view of Remak and others, it is mesodermal, and formed *in situ*. According to the other view, it is ectodermal. Balfour and Onodi, who have maintained the latter view, differ, however, as to the fundamental origin of the sympathetic system—Balfour regarding each sympathetic ganglion as an offshoot from the spinal nerve, while Onodi considers it as a direct proliferation from the spinal ganglion.

For the present research, mammalian embryos were exclusively employed. The stage in development was first considered in which the sympathetic system was plainly visible; and from this point the earlier and later steps in the process were traced.

The first event to occur is the formation of the main sympathetic cord, which arises in the mesoblast on either side of the aorta, as a solid, unsegmented rod of fusiform cells produced by the differentiation of cells *in situ*, and not at first connected with the spinal nerves. In front, it ends abruptly at the level of the first vertebral segment; behind the suprarenal body (to which it sends a considerable cellular bundle) it becomes indistinct, terminating at the level of the hind limbs.

This cellular column is, secondly, connected to the spinal nerves by the formation of the white *rami communicantes*. This is effected by the gradual growth of the inferior primary divisions of the nerves, and their final division into *somatic* and *splanchnic* branches. The splanchnic branch extends into the splanchnic area, where it meets and joins the cellular sympathetic cord. In the anterior part of the thorax it appears to end wholly in the cord; in the posterior thoracic and lumbar regions it divides into two parts, of which one joins the cord, the other passes beyond it. In both cases the fibres joining the cord are directly connected with the component cells. Behind the loins the splanchnic branches cease, and in the neck they do not join the sympathetic cord.

The formation of ganglia in the main sympathetic cord occurs subsequently, and is due to (1) the function of the splanchnic branches, the accession of a large number of nerve-fibres at the point of entrance, and the consequent persistence of the component cells (which are joined by these nerves) as ganglion cells; and (2) the anatomical relations of the cord to the bony segments, vessels, &c., over which it passes, and which indent it at certain points. This view is supported by the evidence obtained from dissections of human embryos in the 3rd, 4th, 5th, and 6th months, where the cord forms a band, constricted irregularly at considerable intervals, and from the adult structure, where the "segmentation" of the sympathetic cord is apparent rather than real.

The cervical portion of the embryonic sympathetic cord separates at the origin of the vertebral artery into two unequal parts. The smaller forms a fibro-cellular cord, and accompanies that artery as the vertebral plexus; the larger portion becomes constricted off from the main sympathetic cord by the formation of a fibro-cellular commissure, and forms the "superior cervical ganglion." When the middle cervical ganglion is present, it may be looked upon as a mass of the original cells of the sympathetic cord which have been included in the growth of the commissure.

Posteriorly the sympathetic cord gradually extends from the level of the hind limbs, until in older embryos it can be traced for a considerable distance along the middle sacral artery. It is not joined by splanchnic branches behind the loins.

The peripheral branches from the sympathetic cord arise as cellular outgrowths which accompany the parts of the splanchnic branches which do not join the sympathetic cord into the splanchnic area. They form considerable nerves, which follow the main vessels, and produce parts of the splanchnic nerves, the solar plexuses, &c., as well as the medullary portion of the suprarenal body. The gray *rami communicantes* appear to arise in the same way, and to belong to the same category.

The main conclusions derived from the above investigations are that in its development the sympathetic cord in mammals is mesoblastic, formed *in situ*, and primarily unsegmented, and unconnected with the spinal nervous system.

Linnean Society, May 1.—Mr. J. G. Baker, F.R.S., Vice-President, in the chair.—Mr. Miller Christy exhibited and made remarks on specimens of the so-called Bardfield oxlip, which he had found growing abundantly not only in the neighbourhood of Bardfield, Essex, but over a considerable area to the north and west of it.—Mr. Buffham exhibited under the microscope specimens of *Myristrichia claviformis* with plurolocular sporangia, and conjugation of *Rhabdomena arctuatum*, found upon *Zostera marina*.—The Rev. Prof. Henslow exhibited a collection of edible Mollusca which he had recently brought from Malta, and described the native methods of collecting and cooking them.—Prof. Stewart exhibited some spirit specimens of a lizard, in which the pineal eye was clearly apparent.—Mr. Sherring exhibited a series of excellent photographs which he had taken near Falmouth, and which showed the effects of climatic influence on the growth of several subtropical and rare plants cultivated in the open air.—A paper was then read by Prof. W. Fream, on a quantitative examination of water-meadow herbage.—This was followed by a paper from Mr. R. I. Pocock, on some Old World species of scorpions.

Zoological Society, May 6.—Prof. W. H. Flower, F.R.S., President, in the chair.—The Secretary read a report on the additions that had been made to the Society's Menagerie during the month of April 1890; and called special attention to two examples of Simony's Lizard (*Lacerta simonyi*) from the rock of Zalmo, Canaries, obtained by Canon Tristram, F.R.S., and presented to the Society by Lord Lilford.—Mr. Sclater exhibited and made remarks upon the stuffed head of an Antelope, shot by Commander R. A. J. Montgomerie, R.N., of H.M.S. *Boadicea*, in June 1890, near Malimdi, on the East African coast, north of Zanzibar. Mr. Sclater referred this head to what is commonly called the Korrigum Antelope (*Damalis senegalensis*).—Prof. Howes made remarks on a dissection of the cephalic skeleton of *Hatteria*, and pointed out some features of special interest exhibited by this specimen. These were the presence of a pro-atlas and the existence of vomerine teeth, as in *Palæohatteria*.—Two letters were read from Dr. Emin Pasha, dated Bagamoyo, March 1890, and announced that he had forwarded certain zoological specimens for the Society's acceptance.—Mr. H. Seebohm exhibited and made remarks on a specimen of the Eastern Turtle (*Turtur orientalis*), killed near Scarborough, in Yorkshire.—Prof. F. Jeffrey Bell read the first of a series of contributions to our knowledge of the Antipatharian Corals. The present communication contained the description of a particularly fine example of the Black Coral of the Mediterranean, and an account of a very remarkable Antipathid from the neighbourhood of the island of Mauritius.—A communication was read from Mr. E. N. Buxton, containing notes on the Wild Sheep and Mountain Antelope of the Algerian Atlas, taken during a recent excursion into that country. These notes were illustrated by the exhibition of fine mounted specimens of the heads of these animals.—Mr. R. Lydekker read a note on a remarkable specimen of an antler of a large Deer from Asia Minor, which he was inclined to refer to an abnormal form of the Red Deer (*Cervus elaphus*).—Mr. F. E. Beddard read a paper on the minute structure of the eye in some shallow-water and deep-sea species of the Isopod genus *Arcturus*. He pointed out that in all the deep-sea forms there was some change in the visual elements which indicated degeneration.—Mr. E. T. Newton gave an account of the bones of some small birds obtained by Prof. Nation from beneath the nitrate beds of Peru. These bones seemed to occur in considerable abundance, and nearly all appeared to belong to one small species of Petrel, which it was thought most nearly resembled *Cymochorea leucorrhoa* or *C. markhami*, the latter of these being now found living on the coast of Chili.—A communication was read from Dr. Mivart, F.R.S., containing notes on some singular Canine dental abnormalities.—Mr. H. Elwes read descriptions of some new Indian Moths.

Chemical Society, May 1.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—An investigation of the conditions under which hydrogen peroxide is formed from ether, by Prof. W. R. Dunstan and Mr. T. S. Dymond. The authors have investigated the conditions under which hydrogen peroxide is formed from ether (compare Richardson, Chem. Soc. Proc., 1889, 134), and found that ordinary ether, prepared from methylated spirit, yields hydrogen peroxide when exposed for several months to sunlight or the electric light. Contrary, however, to the usual statements, pure ether (either wet or dry) and ordinary ether which has been purified by treatment with dilute chromic acid do not give a trace of hydrogen peroxide when exposed to light under similar conditions. An experiment shows that neither water nor dilute sulphuric acid form hydrogen peroxide when exposed to light in contact with air; the authors refer the production of the peroxide from ether to the presence of a minute quantity of some impurity in the ether employed. Hydrogen peroxide is formed when ozone acts on ether in the presence of water, and is also produced under certain conditions during the slow combustion of ether in contact with water.—Paradesylphenol, by Dr. F. R. Japp, F.R.S., and Mr. G. H. Wadsworth.—Note on Benedikt's acetyl values, by Dr. J. Lewkowitsch.

Mathematical Society, May 8.—J. J. Walker, F.R.S., President, in the chair.—The President announced that a member of the Society, Lieut.-Colonel J. R. Campbell, had asked to be allowed to give a donation of £500 to the Society, the sum to be invested, or otherwise made use of, for the good of the Society, in any way the Council should judge best. On the motion of the Treasurer, (A. B. Kempe, F.R.S.), seconded by S. Roberts, F.R.S., the following resolution was carried unanimously: That the cordial thanks of the London Mathematical Society be given to Lieut.-Colonel Campbell for his generous gift of £500 to the general fund of the Society.—The following communications were made:—On the function which denotes the excess of the divisors of a number which $\equiv$ 1, mod. 3, over those of a number which $\equiv$ 2, mod. 3, by Dr. Glaisher, F.R.S.—A table of complex multiplication moduli, by Prof. Greenhill, F.R.S..—On bicircular quartics, by R. Lachlan.—On the genesis of binodal quartic curves from conics, by H. M. Jeffery, F.R.S.—On the arithmetical theory of the form $x^3 + ny^3 + n^2z^3 - 3nxyz$, by Prof. G. B. Mathews.

Paris.

Academy of Sciences, May 6.—M. Hermite, President, in the chair.—Heats of combustion of the principal nitrogen compounds contained in living bodies, and their *rôle* in the production of animal heat, by MM. Berthelot and André. The data and results are given for sixteen nitrogenous bodies. The average heat of combustion is 9400 cal. for fatty bodies, 5700 cal. for albumenoids, and 4200 cal. for carbohydrates, taking 1 gram of each substance. The conclusion is drawn that a weakening of the organism with diminution of power of consumption of the food digested shows itself first by general deposition of the most difficultly eliminated substances, fatty matters, then by failure to get rid of nitrogenous bodies, and finally by incapacity to consume the carbohydrates.—Some remarks on the subject of spherical functions, by M. E. Beltrami.—Remarks on the loss of virulence in cultures of *Bacillus anthracis*, and on the insufficiency of inoculation as a means of estimating it, by M. S. Arloing. It is known that in a culture of the *Bacillus anthracis* left to itself the virulence after a time disappears. The author gives details of the phenomenon and some results of an examination of various cultures.—MM. Bertrand, Tisserand, and Poincaré reported on a memoir by M. Cellérier entitled "On Variations of Eccentricities and Inclinations." The memoir deals with equations of movement, planetary perturbations, the development of the perturbing function, the study of secular variations, and the differential equations which define them.—On fields of magnetic rotation, by M. W. de Fonvielle.—On algebraical integrals of differential equations of the first order, by M. Painlevé.—Solar phenomena observed during 1889, by M. Tacchini. The distribution in latitude of protuberances, faculæ, spots, and eruptions is given.—On the polarization of electrodes, by M. Lucien Poincaré. The author shows that in the case of melted salts the maximum polarization decreases with the temperature, and becomes *nil* at the temperature of decomposition of the salt, the change is gradual with silver poles, but with gold electrodes there is a sudden fall at the point of decomposition of the electrolyte. Admitting that the maximum of polarization is equal or superior to the equivalent of the energy expended in the electrolytic action, the results point to the theory that an elevation of temperature tends to dissociate a salt by the separation of the two ions of which it is composed, just as occurs, according to M. Arrhenius, in a weak solution.—On the preparation and properties of tetrafluoride of carbon, by M. H. Moissan.—On the reduction of nitric acid to ammonia and a method of estimation of this acid, by M. E. Boyer. The author indicates the exact conditions under which nitric acid may be entirely reduced to ammonia when acted upon by hydrogen liberated in the solution by the action of Zn upon hydrochloric acid, and gives analyses which show that his method yields trustworthy quantitative results.—On the molecular refracting power of salts in solution, by M. E. Doumer. It is shown that the law of molecular refraction is best exemplified when one considers the solutions in a state of dilution such that the density of the salt in the solution, taken in relation to the density of hydrogen, may be equal to the molecular weight of the salt.—The action of oxygenated water upon the oxygen compounds of manganese; Part 2, action upon permanganic acid and the permanganates, by M. A. Gorgeu.—On the amethylcamphophenolsulphonate and a derived tetranitrated yellow colouring-matter, by M. P. Cazeneuve.—Note on tridymite and christobalite, by M. Er. Mallard.—On the zeolites of gneiss from Cambo (Basses Pyrénées), by M. A. Lacroix. It is noted that the zeolites are remarkable for their abundance and the beauty of their crystals. They occur in two distinct beds: (1) in acid gneisses, (2) in basic gneisses. Descriptions of the crystals are given.—On a new method for the analysis of straw, by M. Alexandre Hébert.—On the *rôle* of green manures as nitrogenous dressing, by M. A. Muntz. The author concludes from the results of some experiments that the efficacy of green manures as nitrogenous dressing depends especially on the facility with which the fresh vegetable matters allow the nitrification of the proteids and on the favourable influence which they exercise on the physical properties of soils.—Experiments relative to the transmissibility of hæmoglobinuria to animals, by M. V. Babes.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

A Class-Book of Geography: W. B. Irvine (Relfe).—A Hand-book of European Birds: J. Backhouse (Gurney and Jackson).—Larva Collecting and Breeding: Rev. J. S. St. John (Wesley).—A Course of Lectures on the Growth and Means of Training the Mental Faculty: Dr. F. Warner (Camb. University Press).—Pure Logic, and other Minor Works: W. S. Jevons (Macmillan).—Terminologia Medica Polyglotta: T. Maxwell (Churchill).—A Guide to the Exhibition Galleries of the Department of Geology and Palæontology in the British Museum (Natural History), Parts 1 and 2 (London).—Geologisk kart over de Skandinaviske Lande og Finland: H. Reusch (Kristiania).—The Elements of Machine Design; Part 1, new edition: W. C. Unwin (Longmans).—Annual Report of the Department of Mines, N.S.W., for the year 1888 (Sydney, Potter).—Seventh Annual Report of the U.S. Geological Survey 1885–86: J. W. Powell (Washington).—The Chemistry of Paints and Painting: A. H. Church (Seeley).—A Smaller Commercial Geography: G. G. Chisholm (Longmans).—Les Aguas Minerales de Chile: Dr. L. Darapsky (Valparaiso, Helfmann).—Notes upon a Proposed Photographic Survey of Warwickshire: W. J. Harrison (Birmingham).—Fjeld og Jordarter i de Skandinaviske Lande og Finland: H. Reusch (Kristiania).—Report of Mr. Tebbutt's Observatory, 1889: J. Tebbutt (Sydney).—Notes on Electric Lighting: Rev. G. Molloy (Dublin, Gill).—Imperial College of Agriculture and Dendrology, Tokyo, Japan, Bulletin No. 7: Y. Kozai (Tokyo).

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