THURSDAY, JANUARY 15, 1891.

THE INTERNATIONAL CONGRESS OF HYGIENE AND DEMOGRAPHY.

INTERNATIONAL Congresses on Hygiene have been held at about two years' interval in various capitals of Europe since the year 1877. The first was held at Brussels under the especial auspices of the King of the Belgians, and was accompanied by an Exhibition of Sanitary Appliances. After the second of these Congresses, it was decided to associate with the Hygienic Congress one on the cognate subject of demography, which may be defined as the science of statistics applied to the social well-being of the people. The Congress which will assemble in London in August next will be the seventh on hygiene, and the fifth on demography. The last Congress was held at Vienna under the auspices of the Crown Prince Rudolf in 1887. It was then settled that the next Congress was to be held in London, and the year 1891 was selected; because the organizers of the French Exhibition had already announced Congresses on cognate subjects to be held in 1889 in Paris.

The object of these Congresses is to promote the interchange of views between those persons in various countries who have studied the subjects of hygiene and demography, especially with respect to their bearing upon the welfare of the people, as well as upon the intercourse between nations. So far as regards hygiene, in these days of rapid transit, the sanitary condition of any one nation is more than ever a matter of concern to its neighbours, and assemblies of delegates of different nationalities for the discussion of hygienic problems, and the comparison of hygienic methods, are of great importance. For instance, among the most prominent of the subjects which have been treated at these Congresses, has been that of quarantine. England has for some time maintained the view that the efficient sanitation of a country, and especially of seaport towns, is a better safeguard against the importation of cholera than any measures of quarantine. No doubt England has been somewhat at a disadvantage in maintaining its argument, because, whilst it has attended carefully to the sanitation of this country, it has allowed the sanitation of India, which is the birthplace of cholera, to remain in a disgraceful condition. Yet for all that, whilst at the earlier Congresses the views of England upon this important question were entirely set aside, at the last Congress the discussions which had arisen at previous Congresses had so permeated the minds of students of hygiene on the Continent, that it was generally conceded at the Vienna Congress that the enforcement of the laws of health amongst the population of a country was a far more effective measure for preventing the spread of cholera in the country than any measures of quarantine. We may therefore hope that the discussions which will take place at the Congress in London will still further awaken Continental nations to the advantages of sanitation in contradistinction to the absurdities of quarantine; and will also be a means of compelling our Indian authorities to bestir themselves to remove the stigma which now attaches to India of affording a prominent instance of defective sanitation.

In addition to this, numerous social questions intermixed with hygiene now press for a solution, which can be arrived at only after discussion. The term demography is new in this country. Dr. Mouat, the eminent President of the Statistical Society, has, in his late very able address to the Society, given an interesting explanation of the origin of the term. The following extract may advantageously be given here:—

"The term 'demography' is not to be found in any of our dictionaries, even of tolerably recent date, and in France is only contained in the great work of Littré, who denominates it 'a didactic expression descriptive of peoples as regards the population in relation to ages, professions, dwellings, &c.,' and he also adopts the definition of Quetelet, that it is 'the natural history of society.' The appellation appears to have been first employed by M. Galliard in his 'Elements of Human Statistics, or Demography,' published in 1855. The first President of the Society, the late Dr. Bertillon, treated it as dealing with the inner life of the social bodies which form a people (births, marriages, deaths, migrations, &c.), but only in their collective influence, of which it measures the powers of the parts or of the whole, without meddling with biological proceedings, which distinguish it from physiology."

Dr. Bertillon regarded England as the real home of demography, as it surpassed all other nations in the incomparable richness of its demographic inquiries, and in the unbroken continuity of its published returns.

The subjects which will be open to discussion in the Congress may be classed under the following general heads:—(1) The prevention of communicable diseases, as, for instance, (*a*) whether sanitation or quarantine is most efficient against cholera; (*b*) how the spread of disease from milk and from water can be checked; (*c*) the relation which tuberculosis and other diseases in animals bear to mankind; (*d*) vaccination, the prevention of leprosy, rabies, and such like contagious diseases; (*e*) the effect of soil on communicable diseases; (*f*) disinfection and disinfectants. (2) The science of bacteriology in relation to communicable diseases. In connection with this subject an exhibition of microscopic and cultivation specimens would be arranged. (3) Industrial questions, as, for instance, the regulation of industrial occupations from a health point of view, including the length of hours of labour in different occupations, the influence of dwellings upon labour, and the effect of large cities on the health of the population; the influence of the health condition of the people, and the effect of different sorts of food and of wages upon the efficiency of labour. (4) The hygiene of infancy and childhood, as, for instance, protection and insurance of infant life; school hygiene, including length of hours of study, nature of studies, and the effect of physical training; school buildings and their accessories, and other educational questions bearing on health. (5) The hygiene of houses and towns, including questions of width of streets, height of buildings, air space round houses, house construction, water supply, river pollution, drainage, treatment of refuse, disposal of the dead. (6) State hygiene, or the duty of the Government towards the nation in regard to health, and the machinery necessary for exercising that duty; the duties of communities towards each other in regard to questions of health, and towards the individuals of which they are composed; the laws for notification and isolation of disease; the status and education of medical officers of health and of sanitary inspectors.

In consequence of the wide scope covered by these subjects, it is proposed that the work of the Congress shall be divided between ten Sections. The order in which they will stand is not finally settled, but they may be briefly summarized as follows:—(1) Demography, which necessarily involves questions of industrial health; (2) communicable diseases; (3) bacteriology; (4) diseases of animals in relation to man; (5) hygiene of infancy and childhood; (6) engineering in relation to hygiene; (7) architecture in relation to hygiene; (8) chemistry in relation to hygiene; (9) military and naval hygiene; and last, but not least important, (10) the functions of the State in relation to hygiene.

The Prince of Wales, who has so deep a personal interest in all matters relating to the well-being of the community, at once acceded to the request made to him to accept the post of President of the Congress; and the British Presidents and other officers of Sections will be among the most eminent men in their several departments of knowledge. Upon them will lie the duty of organizing the work of the several Sections before the Congress meets. They will be supplemented at the meeting of the Congress by foreign or colonial and Indian representatives, distinguished in the several branches of science included in the programme. It may be mentioned that above 2000 members, exclusive of representatives from Great Britain, attended the Vienna Congress; and it is anticipated that the Congress in London will attract at least an equal number of persons from foreign countries, because Great Britain affords so many examples of important sanitary works, as well as of institutions having the preservation or restoration of health as their main object.

The expenses of correspondence and other matters connected with the organization of the Congress are so large that appeal is made to those interested in the subjects to be discussed to aid the work by moderate contributions.

GEOLOGICAL TEXT-BOOKS.

Class-Book of Geology. By Archibald Geikie, F.R.S. Second Edition. (London: Macmillan and Co., 1890.)

Elementary Geology. By Charles Bird, B.A., F.G.S. (London: Longmans, Green, and Co., 1890.)

ALL who care for geology, teachers and students especially, will hail with delight the appearance of a second edition of Dr. A. Geikie's "Class-book." All the more that it may now be had at less than one-half the cost of the first edition. Such a substantial reduction in the price of a scientific book is a piece of liberality and far-seeing policy which it could be wished were more common. Too often, when a rapid sale of such a work has proved that its value is appreciated and its success assured, there seems to be a feeling that its established reputation may be relied upon to ensure a demand for it in the future equal to that of the past, and that it will be quite safe to keep up its price. But no such purely mercantile views have prevailed here, and we may feel sure that both publishers and author have been actuated first of all, in the bold step they have taken, by a wish to promote the extension of knowledge by placing within the reach of as many as possible a work so well got up, so admirably illustrated, and so full of matter presented in an eminently readable form. And there can be little doubt that this disinterested conduct will reap the reward it deserves. Many a teacher will bear me out that the book has been a universal favourite. Students who would not put up with the dry compendium of the normal text-book have been won over by its attractive style; and even those earnest workers, who despise or excuse the absence of literary elegance, have found their labours lightened and have felt an added pleasure when their first introduction to geology has been through the medium of this class-book. One thing only prevented its being adopted far and wide as a text-book in the school and lecture-room. Now that obstacle is removed, it is sure to come into more and more extensive use; and it may be confidently predicted that a rapidly increasing sale will soon recoup those concerned for y temporary loss that their generous treatment of the public may at first occasion.

It is the conviction that it will not be long before a second opportunity for revision presents itself, and a wish to give, if it can be done, some help towards making so excellent a book more perfect still, that embolden me to be critical, and to point out a few minor points which seem capable of emendation; and I take this course with the less hesitation, and with no fear of being misunderstood, because I have endeavoured, in a previous notice of the first edition, to do justice to the many excellences of the work and to explain its scope.

I cannot say that the account of the formation of "flood plains," on p. 39, quite commends itself to my mind. The author postulates the existence of an alluvial flat, over which sand and silt are deposited during floods, but he does not explain how this flat is produced. Possibly the required explanation may be found in his "Physical Geography," which he recommends should be read in connection with the present work. If this be so, a reference to the passage required would be useful: indeed, wherever the one book is required for the elucidation of the other, it might be well to call attention to the fact in a note. The impartial and judicious blending of Darwin's and Murray's views on the growth of coral reefs is much to be commended. If we take into account the vast number of cases in which minerals occur without any external crystallized shape, it seems hardly safe to say that they have "in most cases a certain geometrical form" (p. 123). But the mineralogical sketch seems capable of improvement in more than one direction. The using "sides" and "faces" as if they were convertible terms, in the description of rock-crystal on p. 124, is apt to engender confusion of thought. In the account of felspars there is no mention of their cleavages, a property so often of practical value in distinguishing them from quartz, and a property far more easily recognized by the beginner than their monoclinic and triclinic crystallization. In some cases—mica, for instance—there is no mention of hardness, where that is a character useful in identification. It would not be fair to blame a geologist for the definition of the systems of crystallization given in the book before us, as long as it still survives in treatises on mineralogy. But it is much to be desired that the number and position of certain ideal axes should not be the starting-point for classification. If the grouping were based on the degree of symmetry possessed by each system, and it were afterwards, if necessary, pointed out that ideal axes had their uses, the point of real importance would have its due place, and things of subsidiary value would find their proper level. But, really, the amount of crystallography that there is room for in an elementary treatise on geology is so small, and it is so hopeless to attempt in this space to convey any idea of what crystallography means, that the subject in its general form had better be passed over altogether; it would be quite enough to explain what is meant by crystalline cleavage, and to call attention to the shape of crystals only in those cases, such as fluor spar and calcite, where they are common and easy to recognize. Many a student, who would simply be driven wild by an attempt at a systematic teaching of crystallography, has an eye good enough to enable him to recognize dog-tooth spar when he sees it, and to form a very fair idea whether an hexagonal pyramid is dumpy enough to belong to quartz. In teaching, it is quite enough, as a rule, to let the small amount of crystallography that a geologist must know drop in incidentally as occasion requires, taking special care that each fact is illustrated by a concrete example, so that the knowledge required may come in instalments and be assimilated bit by bit.

To continue in the censorious mood. The statement that "perlitic structure is one of the accompaniments of devitrification" (p. 145) is fraught with danger. Many readers, I fear, would take the words to imply that the structure is a result of devitrification, which of course is not their meaning. Why not say, "is often found in devitrified rocks, and is useful as indicating that they were once glassy"? I take decided objection to the statement, on p. 150, that grains of sand are usually rounded; as a rule, the sand-grains of a sub-aqueous sandstone are most markedly chips, and it is only when they have been exposed to æolian wear that they become even approximately rounded. The author is wisely guarded when he treats of the origin of flint; but the doctrine of the replacement of calcium carbonate by silica has so much in its favour, that it might, without much risk and with manifest advantage, have been mentioned. That quartzite is "an indurated siliceous sand" we shall all admit: it might have been usefully added that in many cases the induration has been caused by the deposition of secondary silica between its grains. In discussing the methods by which sedimentary deposits are consolidated, no mention is made of the tangential pressure exerted during great earth movements; surely this is one of the most, if not the most efficient agent in the work.

The stratigraphical part of the book is necessarily brief, but it is all to the point, and the reader ought to carry away from it clear notions as to the main features in the life and physical geography of each geological period. It is here that the distinctive excellence of the work, which places it so far above the level of the average dismal text-book, comes out most strongly. In the place of comparative tables of strata and lists of characteristic fossils, which an examinee commits to memory and forgets, we have graphic pictures of what England, and Europe in many cases, were like, and an account of what went on during geological periods—history, in fact, and written as an historian, and not as a compiler, writes. The illustrations are excellent: the author's well-known artistic skill adds a charm to the usefulness of many; and the figures of minerals, rock structures, and fossils are such faithful pictures, that, where a teacher is quite unable to procure specimens, they will to a large extent supply the want. The book closes with an appendix giving the classification of the vegetable and animal kingdoms, in which those points which are of special importance in palæontology have been judiciously picked out and made prominent.

In the preface to Mr. Bird's "Elementary Geology," we are told that "the following lessons were given to a class of thirty boys, and were very successful in arousing an interest in geology and in sending a number of town boys on long walks into the country;" and that they had also the comparatively unimportant result of enabling the class "to pass the South Kensington examination in the elementary stage of the subject." I have the best possible reason for feeling sure that the class-teaching of the author would deserve and secure the good results which he tells us followed from it. But I have grave doubts whether a beginner, who had the book alone to rely upon, would be won over to feel any great love for its subject. This, however, is no fault of the author's. As long as the main end of study is to enable the student to pass examinations, books must be written whose chief object is to help him to this end; they must be cheap, and therefore small; so they must be thickly packed. The second chapter of the work before us is an instance of how this must be done. It consists really of a definition of nearly all the terms which are to be used in the course of the work, and the reader who commits it carefully to memory will be armed with answers to a large number of the questions that may be put to him in examinations. But I am perfectly certain that Mr. Bird never gave a lesson in class, or a series of class-lessons, which is fairly represented by this chapter. No human being could survive the tedium which must be the result of thrusting upon him at one fell swoop such a crowd of new words and new conceptions. The success which crowned Mr. Bird's labours is in itself a proof that he never taught in this fashion; enthusiasm such as he kindled is not evoked by overwhelming the learner with a flood of dry statements at the outset of his career. That is just the way to create a distaste for a subject which no amount of subsequent amplification suffices to remove. Definitions we must have, but one who can teach like Mr. Bird knows how to bring them in one by one, at intervals, as they are wanted. Why his book is so unlike what must have been the style of his teaching has been explained already, and it is only giving him his due to confess that, considering how he has been trammelled, he has executed his task well, and that the book is above the average level of its class. He will, I am sure, allow me to point out, in no unkindly spirit, portions which seem capable of improvement.

There is the same crowding in chapters iii. and iv. as in chapter ii. The descriptions of the minerals in chapter iii. might enable a reader to answer some questions often set in examinations, but in many cases they would do little towards helping a student to know the mineral when he saw it, and this after all is what the real student wants. To learn how to worry out for himself that a mineral is probably a felspar is infinitely more valuable as a bit of educational discipline than to be able to write down in an examination the chemical composition of felspars. If only a few of the commoner rock-forming minerals had been treated of, it would have been quite possible in the space available to have given descriptions of the way in which a student must go to work in order to recognize them; but then some minerals must have been omitted that are liable to be "set" in examinations.

There are in the book many little slips, not very serious, which might usefully be corrected when opportunity offers. On p. 28 it should be stated that clay is hydrated. There is hardly reason to say that quartzite has been "almost melted" (p. 42); it is certain that in many cases its hardness is due to the deposition of secondary silica. It would have been as well to give some account of the physical characters of serpentine (p. 43), and greater definiteness of statement as to the minerals by the alteration of which it has been produced. I really hardly know what grounds there are for the statement, on p. 78, that the action of glaciers has had any thing to do with the production of immense perpendicular cliffs of limestone. One would have liked to see a section somewhat nearer the actual thing in the place of our old time-honoured friend the section across the Jura on p. 98. I am not sure, but I fear, that the dissolution of actual chalk in carbonated water would go on slowly (p. 45); freshly precipitated calcium carbonate dissolves fast enough, and is safer for lecture-room experiment. It is not carbonate of iron that gives a bluish-grey tint to rocks, as stated on p. 47. In chapters vii. to xi. it would seem that we have a much closer representation of the author's actual teaching than in the earlier part of the book; there is much life and brightness about them; and, while they are full of matter, it is presented in an attractive form. It would have been well to give distinctly the two main points of difference between Conchifers and Brachiopods on p. 113. The only character mentioned is that the latter are equilateral. The Trilobite on Fig. 110 is not a Paradoxides. The section on Fig. 139 is misleading; the Permian scarp nowhere towers above the Penine ridge in the way represented. It would certainly be desirable to add a word about the Alpine Trias on p. 169. The position of the siphuncle in Goniatites is incorrectly stated on p. 181. By a curious slip the Portland Beds get the credit of Mammalian remains on p. 193. In the figure of Inoceramus, on p. 213, the cartilage-pits of the hinge are described as teeth. In the notice of the Forest Bed, on p. 226, room might be found for a word about the Arctic Freshwater Bed.

After all this fault-finding, it is a pleasure to be able to call attention to the excellent character of the illustrations: they are numerous, well chosen, and admirably executed; the figures of fossils deserve special praise. The geological map of the British Isles will be most useful. It is not crowded, and the clear transparency of the colours is such as till lately was unknown in English chromolithography. The book belongs to a class that I have no great love for, but it is distinctly good of its kind; and it will prove useful in the hands of a teacher who knows how to dilute and season the condensed food which it offers, and whose aim, like the author's, is not merely to get his students through an examination, but to educate them and imbue them with the scholar's disinterested love for learning. A. H. GREEN.

ELECTRO-METALLURGY.

The Art of Electrolytic Separation of Metals, &c. (Theoretical and Practical). By G. Gore, LL.D., F.R.S. *Electrician* Series. (London: The *Electrician* Publishing Co., 1890.)

A Treatise on Electro-Metallurgy. By W. G. McMillan, F.I.C., F.C.S. Griffin's Scientific Text-books. (London: Charles Griffin and Co., 1890.)

ANY metallurgical process which reduces the cost of production as compared with older processes for effecting similar results must of necessity prove of great commercial importance. This is especially the case in places where labour is dear and unskilled, and fuel and refractory materials both scarce and costly—perhaps, even, absolutely unobtainable. If, too, the new process enables a metal to be produced, as in the case of copper, which possesses superior quality to the metal produced by the older process, such a metal will command a higher market price, and the use of the new process is consequently attended with important commercial advantages.

Such an improvement over ordinary metallurgical processes has been effected in recent years by the gradual introduction of electrolytic methods. They have not, however, made the rapid progress which was at one time anticipated, and at present are practically only of importance in the metallurgy of copper. There are many reasons for this. The tendency to-day is to endeavour to increase to its maximum the daily output of existing works, provided the product already attainable is of fair quality, rather than to lay down new plant, which, although it might produce a metal of greater purity, would be severely handicapped by the slowness of the work and smallness of the output as a return for the capital invested. It is in this respect that electrolytic methods for the preparation of the ordinary commercial metals fail to give satisfactory results. It is true that in the cases of gold and silver this objection does not to so large an extent apply, but, unfortunately, other circumstances have also to be considered. The metallurgy of the precious metals is for the most part effected in the immediate neighbourhood of the mines, and these, in turn, are usually situated in out-of-the-way districts. Miners, too, and mill-men are generally but slightly acquainted with a knowledge of matters pertaining to electrolytic methods, and comparatively little attention has therefore been directed in the past to the treatment of the ores of the precious metals by such methods. There can, however, be but little doubt that in the near future this will cease to be the case, and that by the improvement of known methods, and by devising new ones, electrolytic methods will attain a degree of commercial importance which at present can hardly be foreshadowed. Any sound contribution to the literature of the subject which is likely to assist in this development of metallurgical processes thus becomes of much importance. We record, therefore, with pleasure, the appearance of a manual by Dr. Gore, devoted to electro-metallurgy proper, which is likely to prove of much use in the spread of the theoretical knowledge so requisite for industrial success. The author gives much attention to this portion of the subject, but in view of the claim "that this book is written to supply a want," it is to be regretted that fuller details are not forthcoming as to the practical working of the processes, though such information as is given is well and clearly put. The greater part of it, however, has already appeared elsewhere. In the case of copper, for instance, if the working arrangements are faulty, the mud liberated on the solution of the impure copper may be deposited again on the cathodes; the tank solution, too, may vary in density, and the working become irregular with a consequent irregularity in the character of the metal produced. Here, again, excessive rapidity, fatal to the purity of the product, is very common, the result being that in the majority of instances it is necessary to melt the deposited copper, thus introducing sources of error which it is one of the main objects of the process to avoid. The incidental collection of the gold and silver in copper submitted to such a refining process may occasionally cease to be an incident and become the main object of the process, ores of gold and silver being intentionally added in the previous smelting operations.

The difficulty of obtaining admission to works employing electrolytic refining methods, which the author himself laments, is so great, that it is with all the more regret that we have to call attention to this want of fuller details as to the more recent modifications of working adopted in this country and elsewhere. The text-book is otherwise an excellent one.

The term "electro-metallurgy" has been generally applied in the United Kingdom to all operations in which a metallic deposit is produced by means of electrolysis, however small the scale of production may be. Such a designation of the art is much too broad, and it would be better to limit the use of the term "electro-metallurgy" to those processes which are employed on a large scale for the purpose of extracting or refining metals, as distinguished, that is, from ordinary galvanoplastic methods.

This criticism applies to the "Treatise on Electro-Metallurgy," by Mr. W. G. McMillan, the greater part of which relates to galvanoplastic methods proper. Metallurgical processes, however, are also considered, though but little space is given to them; and a chapter, which might well have been a longer one, is devoted to electrolytic methods of assay.

Dr. Gore, after giving a brief historical sketch of the subject, passes to a consideration of the theory of electrolysis, which is considered at some length, useful tables being also given. The mode of establishing an electrolytic refinery, together with the plant required for this purpose, is next considered, and in addition to an account of the various types of dynamo-electric machines in use for electrolytic purposes, brief descriptions are also given of the various electro-metallurgical processes which have been from time to time proposed.

In Mr. McMillan's treatise, an historical introduction to the subject of electro-metallurgy is given, accompanied by a theoretical consideration of the question. A chapter is devoted to the "sources of current," and in a series of other chapters the art of electro-plating is described. Another chapter refers to electro-typing, and others relate to the electro-deposition of the various metals and some alloys. Electro-metallurgical processes proper are also considered, together with methods of assay, and a glossary is added of substances commonly employed in electro-metallurgy. Forty-three useful tables are given as addenda, and the printing is clear and distinct.

We can recommend both these manuals, not only to students, but also to those who are interested in the practical application of electrolytic processes.

OUR BOOK SHELF.

Leçons sur l'Électricité professées à l'Institut Électro-Technique Montefiore annexé à l'Université de Liége. Par Eric Gerard. Tome II. (Paris: Gauthier-Villars et Fils, 1890.)

THIS volume completes the work the first part of which has been already noticed in NATURE (vol. xlii. p. 219). In the first volume, the general principles of electricity and magnetism and the theory of dynamo-electric machinery were explained; the volume now before us contains a very clear and full account of the most important industrial applications of electricity. The principal subjects discussed in this volume are: methods of distribution in electric lighting; transformers, and meters; the insulation of electric light cables; electric motors, both with constant and alternating currents; the transmission of power; electric railways and tramways; descriptions of the various kinds of incandescent and arc lamps; photometry; electro-metallurgy, including the deposition of metals from solutions and fused salts; electric welding. All these subjects are clearly explained, and generally illustrated by instructive diagrams and figures; the book is well up to date, and should prove of great service to students of electric technology. The only fault we have to find with it is that it contains no references which would enable the student to consult for himself papers in which the various processes are described more fully than is possible in a text-book of moderate size. This omission, though exceedingly common in French treatises, is one which we think is greatly to be deplored: in the first place, it leaves the student at the mercy of the author, for, if he does not understand the explanations in the text-book, he does not know where to turn for another with which he might have a better fate; and secondly, we hold that the habit of consulting papers in the Transactions of learned Societies and scientific journals is a most valuable one for the student to acquire, and that it has no chance of developing unless text-books contain references to such papers. J. J. T.

Fathers of Biology. By Charles McRae, M.A., F.L.S. (London: Percival and Co., 1890.)

STUDENTS of anatomy and physiology, as the author of this little book points out, are apt to suppose that the facts with which they are now being made familiar have all been established by recent observation and experiment. There could not be a greater mistake. Biology is a science of "venerable antiquity," and the way was prepared for modern discoveries by the labours of many patient and far-seeing investigators. In the present volume Mr. McRae has sought to illustrate this by sketching the biological work of Hippocrates, Aristotle, Galen, Vesalius, and Harvey. He could not have selected five inquirers better suited for his purpose; and within the limits he has allotted to himself he has succeeded admirably in indicating the nature and value of the contribution which each of them made to biological science. He is especially happy in his treatment of the three representatives of ancient research; but the essays on Vesalius and Harvey are also clear, well-arranged, and suggestive. Mr. McRae is not content with second-hand information. He has evidently studied the original sources with care; and the result is that his method of exposition is invariably fresh and interesting. He knows, too, how to connect the results attained in former times with those at which later anatomists and physiologists have arrived. He does not, of course, claim to have exhausted the interest of his subject. But the work he has done, so far as it goes, is sound, and should be of service to many of his readers in helping them to understand the various stages in the development of the scientific conceptions with which he deals.

Through Magic Mirrors. By Arabella B. Buckley. (London: Edward Stanford, 1890.)

THIS volume is intended to form a sequel to the "Fairy-Land of Science," and is written with the clearness and brightness which make that book so attractive. The power that Miss Buckley has of interesting young people in the more popular parts of the various sciences cannot be doubted, and is well shown in the present book. A magician is supposed to teach young lads; and the author is thus enabled to bring in different parts of the sciences, and to preserve a continuity throughout.

There are ten chapters, and the following are some of the headings: "The Moon," "Life-History of Lichens and Mosses," "History of a Lava Stream," "An Hour with the Sun," "An Evening with the Stars," "Little Beings from a Miniature Ocean, &c." In the chapters with these headings the uses of the telescope, spectroscope, camera, microscope, &c., are all mentioned and well explained, and their principles clearly brought out.

The information throughout is up to date, and is taken from the best sources; and the illustrations form a most important addition to the text. The frontispiece is a reproduction of Mr. Isaac Roberts's most exquisite photograph of the great nebula of Orion, taken on February 4, 1889.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

The Proposed South Kensington and Paddington Subway.

ALTHOUGH there can be no question but that any facilities of access to the group of buildings on the ground of the Commissioners of the Exhibition of 1851 will be greatly to the advantage of the public, the objections to the proposed railway raised in your recent article on "Shaking the Foundations of Science" are worthy of most serious consideration, if they are not altogether fatal to the scheme. The alternative route for the line which you suggest, along Queen's Gate, would meet with equal difficulties, much greater expense, and certain opposition in several quarters. There is, however, another solution of the question free from most of the objections to both the others.

Let the existing subway be continued as originally projected as a walking road to a station at the Albert Hall; and let the tramway or railway line be brought across Kensington Gardens from Paddington to meet it there. This will have the desired effect of giving easy access to the Albert Hall and neighbourhood from the north-west of London, as well as a convenient dry covered approach from the South Kensington Station. The cost of this scheme to the promoters of the railway will be far less than if they have to enlarge the present subway so as to make it available for carriages. The convenience to the public will be nearly as great. In the proposed scheme anyone coming by the District Railway must change carriages at the South Kensington Station; and there are few who, having once alighted, would not as soon take a short walk to the Museums or the Albert Hall through the subway (as was originally designed when this was made) as mount into another carriage. It will be a totally different thing from having (as now) to emerge to the upper surface, and either take a cab or trudge along a wet, dirty, and cold road. It would, in fact, be scarcely a longer walk than is often necessitated along the platforms of some of our existing railway stations.

The walking subway, instead of opposition, may well receive the cordial support of all interested in the "foundations of science," as it will lessen the number of wheels which rattle along the streets above. The marvellous improvement that it made in the state of the streets during its brief period of usefulness, the summer of the Indian and Colonial Exhibition, was apparent to all dwellers in the neighbourhood.

W. H. FLOWER.

Natural History Museum, January 12.

WOULD it not be desirable to prepare a petition to the House of Commons, to be signed exclusively by scientific men, against the proposed South Kensington and Paddington Subway Railway? A copy might lie for signature at the rooms of each of the learned Societies. ALFRED W. BENNETT.

Chemical Action and the Conservation of Energy.

IN NATURE of December 18, 1890 (p. 165), there appears a paper by Mr. Pickering under the above heading, in which some of the errors of thermo-chemists are exposed. As, on account of the well-known experimental skill of Mr. Pickering in thermo-chemistry, there may be some risk that all the positive statements in this paper may be accepted by students as facts, it is, I think, worth pointing out that some of these statements, although given positively as if they were obvious physical laws, are, to say the least, matters of controversy, whilst others are absolutely erroneous. It would seem as though prolonged calorimetrical studies lead the experimenter to regard heat changes as the only factors to be considered in cases of chemical equilibrium, since the same erroneous view of the subject has been taken by Berthelot in his "Law of Maximum Work," by J. Thomsen in a similar "Law," and now by Mr. Pickering in this paper. He concludes:—

"As a consequence of this, it follows that, in any complex system of atoms, where two or more different arrangements are independently possible, and where the various products remain within the sphere of action, and are capable of further interaction, then those products, the formation of which is attended with the greater evolution of heat, will be formed to the exclusion of the others."

It is somewhat curious that by way of clearing the ground for his own views Mr. Pickering demolishes one of the chief arguments of the older school—namely, that an endothermic reaction may occur if it forms part of a cycle of which the final result is an evolution of heat. His illustration of the impossibility of this, by comparison with a stone rolling a short way up a hill by itself in order to have a long roll down on the opposite side, is exceedingly apt. But immediately following this is a statement which must be regarded as incorrect: "No amount of heating can make an endothermic reaction possible so long as it remains endothermic."

I have characterized two statements as erroneous; perhaps I may be allowed to mention the evidence usually accepted as proving this, premising that, since it partially depends on the second law of thermodynamics, and this in its turn depends upon experiment (see J. J. Thomson, "Application of Dynamics to Physics and Chemistry," pp. 4 and 5), no argument against it is valid which deals only with single molecules. The researches of J. W. Gibbs (Trans. Conn. Acad., iii. 108, 343), of Lord Rayleigh (Proc. Roy. Inst., vii. p. 386), of Massieu (*Journ. de Phys.*, vi. p. 216, and of Helmholtz (*Sitz. Akad. Berl.*, February 2, 1882, July 27, 1883, and *Monats. der Berl. Akad.*, May 31, 1883, p. 647; also, Physical Society, Translated Memoirs, vol. i., Part 1), prove conclusively the general principle that the evolution of heat alone is not conclusive as to the possibility of a chemical change taking place in a given direction. The magnitude which does condition this change having been arrived at by different methods, in some cases independently, has received different names; thus it is the "free energy" of Helmholtz, the "characteristic function" of Massieu, the "force function for constant temperature" of Gibbs, and the "thermodynamic potential" of Duhem. All these names represent the same function, F (or − F), the integral energy (U) less the product of the absolute temperature (T) into the entropy (S); or in symbols the free energy $F = U - TS$. In the above-mentioned researches it is shown that a system will be in stable equilibrium if the free energy is a minimum. Hence, to restate Mr. Pickering's conclusion, it follows that, in any complex system of atoms or molecules, where two or more arrangements are independently possible, then the final arrangement will be such that its formation is attended with the greatest loss of "free energy." Although this work has now been published nearly fifteen years, so far as I am aware no serious attempt has been made to prove it to be inaccurate.

Let the energy, entropy, and temperature before the reaction be U, S, and T; after the equilibrium is established, U′, S′, and T′, then $(F - F') = (U - U') - (TS - T'S')$. But $(F - F')$ must be positive, *i.e.* $(F - F') > 0$. If the temperature be so low that the second term is small compared to the first, then there will be a loss of energy—an evolution of heat. But this is not the only possible case; the reaction may take place with an absorption of heat if $T'S' > TS$, and also $(TS - T'S') > (F - F')$. Here $(U - U')$ is essentially negative; in other words, the reaction will take place of itself and with absorption of heat. This will account for many apparent anomalies in high temperature reactions.

Further, as regards the statement that "no amount of heating can make an endothermic reaction possible so long as it remains endothermic," we see from the equation $F = U - TS$ that the importance of the second term increases with the temperature, and thus F may decrease by the increase in TS as well as by the more generally recognized decrease in U. U may, in fact, increase in the course of the reaction, provided that the corresponding increase in TS is larger.

Exception might also be taken to the definition given of chemical affinity as "the potential energy possessed by atoms." It is rather difficult to imagine potential energy becoming "satisfied" when the atoms combine together. As, however, there are now several works giving a complete account of the other views on this subject, it is unnecessary to discuss this point.

In conclusion, it may be as well to point out that the above remarks contain nothing new, having been known for years; but as they have not yet found their way into the text-books of thermal chemistry, and are apparently ignored by our leading thermo-chemists, it seems worth while to bring them to the notice of students. GEORGE N. HUNTLY.

Richmond, Surrey, December 22, 1890.

Forestry in North America.

THE timber-cutters, graziers, and settlers, who are rapidly destroying the forests of North America have recently obtained a valuable ally in Major J. W. Powell, Director of the United States Geological Survey; who, in his enthusiasm for the construction of dams, appears to care little from whence his countrymen are to get their future supplies of timber, whilst his proposed means for securing to them a perpetual water-supply for irrigating the farm lands below the Rocky Mountains, when confronted with the experience acquired in Europe, are likely to prove worse than useless. Most students of physical geography consider hill forests as efficient aids in storing water, but not so Major Powell; for in the April number of the *Century Magazine* in a paper on the "Non-irrigable Lands of the West," and in another paper published in the August number of the *North American Review*, entitled "The Lesson of Conemaugh," he advocates the denudation of the higher slopes of the Rocky Mountains, in order to allow snow-drifts to accumulate in the folds of the hills, and afford a perennial supply of water for irrigating the drier lands below the forest belt. Major Powell contends that, as long as the higher hill slopes remain forest-clad, the snow falling on them will always be uniformly distributed, and cannot be drifted together by the wind. It therefore melts away gradually, without affording a steady supply of water to the hill streams. He also asserts that in California the hill streams have increased wherever the hills have been denuded; and expresses his opinion that, although forests may be useful in districts with a heavy rainfall, as they evaporate excessive moisture rapidly from the soil, yet in drier regions this rapid evaporation is prejudicial, and therefore forests should be cleared in order to preserve the requisite amount of moisture in the soil. This appears to be a complete inversion of what actually occurs, as I hope to show further on.

Major Powell gives a most striking picture of the ease with which forest denudation may be effected in the dry coniferous forests of the Rocky Mountains. When camping out twenty years ago in this magnificent forest tract, where the growth was then so dense that not a blade of grass was to be found under the trees, but the soil was completely covered with dead needles; the Major allowed his camp fire to ignite a splendid pine tree, and watched the "welcome flame" rising till the whole tree was in a blaze. The fire soon spread to the surrounding forests, and before nightfall the country for miles around was in flames, more timber being destroyed in a few days than "has been used by the people of Colorado for the last ten years."

Major Powell, however, as we have stated, would preserve forests in the damper regions, and admitting the danger of forest fires to their existence, he proposes as a remedy a great extension of sheep-farming; so that the undergrowth of the forests may be nibbled off, and thus a great source of danger from fire may be removed. What the sheep are to find to nibble in forests where the soil is covered with dead needles, it is not easy to say; and if all undergrowth be bitten off by the sheep, the future re-growth of the forest could evidently not be assured by natural seedlings, but the older portions must be gradually fenced and planted up: if this be done on a large scale it is to be feared that even the vast resources of the States would prove inadequate. An answer has, however, already appeared in an American periodical, *Alta California*, to the Major's suggestions regretting the progress of forest arson, and anticipating that thousands of acres of the noblest timber in the world will be destroyed before the first rains next autumn. The writer states that these forest fires are chiefly due to shepherds, who burn the pine needles, and consequently the entire forest, in order to get young grass to spring up for their flocks.

So much for the real results of extending sheep-runs to preserve the forest from fire, which reminds one of a suggestion in Prof. Wallace's "Indian Agriculture"; except that this author goes further than Major Powell, and wishes to induce the Government of India to put an end to the efforts of the Indian Forest Department to protect their forests from fire, considering that Indian forest trees have grown up under a *régime* of annual fires till they have become quite inured to them, and would suffer if the fires were stopped. The Professor also urges that the Indian flocks and herds would miss the fresh young grass always springing up in burned forest, but if admitted to graze in the annually burned area, would keep down the undergrowth, the occasional burning of which in a forest protected from fire, according to him, does more damage than annual fires in well-grazed forests. It is to be feared that both the Edinburgh Professor of Agriculture and the Director of the United States Geological Survey have more sympathy for the shepherds than for the forests.

Besides the paper controverting the Major's advocacy of sheep as friends to the forest, I was glad to see two very sensible articles, in *Garden and Forest* of June 18 and September 4, entirely opposed to his theories, whilst Mr. Abbot Kenney has written a paper in the August number of the *Century* showing that the statement about the increase in volume of the hill streams in California being due to forest denudation, is at variance with the facts of the case.

There can be no doubt that directors of geological surveys should study the action of the forest as a great natural factor influencing soil and climate. In Germany, the elements of forestry are taught in primary schools as a necessary part of the general education of the country people; but the German peasants have owned forests, and participated in their benefits, for centuries, and a forest fire in France or Germany is considered a great calamity by the whole country-side: the Anglo-Saxon race on the contrary has been chiefly engaged during the last 300 years in clearing away the virgin forests of the new worlds in the western and southern hemispheres; and, as we see, the benefits of forests are still questioned by certain influential people both here and in America.

Darwin and A. R. Wallace admit over and over again the inestimable value of the forest as Nature's great conservative force; and in America, Major Powell's heresies were long ago disposed of in Marsh's "Man and Nature." In Wallace's

"Tropical Nature," we read as follows:—"A systematic planting of all hill-tops, elevated ridges, and higher slopes, would probably cure the bad effects of the intermittent rainfall of Central India; whilst the action of forests in checking evaporation from the soil, and in causing perennial springs to flow which may be collected in reservoirs, would serve to fertilize a great extent of country."

Major Powell evidently disagrees with the results of Wallace's observations, but the facts are quite opposed to his theories. Forests do not evaporate moisture nearly so fast as bare ground; and although denuded hill-sides may favour the accumulation of snow-drifts, yet they allow the rainfall to drain off rapidly, and cause dangerous floods; loosening of the soil on hill-sides; avalanches; silting up of river-beds; and frequently give rise to the complete devastation of cultivable lands at the foot of the hills, as the material washed down from above is spread over them by the floods in the form of silt, gravel, and boulders.

In Dr. Schlich's "Manual of Forestry," at pp. 43 *et seq.*, we read that experience in Germany shows evaporation from forests to be only two-fifths of that in the open country, and that the balance of water retained in forest soil increases rapidly with the altitude, so that evaporation in mountain forests may be reduced to about 10 per cent. of the rainfall. We also know that, in France and Germany, mountain forests have long been looked upon as preservers of moisture and feeders of springs. In 1889, the French Government spent 3,192,800 francs in *reboisement* works in the Alps, Pyrenees, and Auvergne; and this almost entirely for the indirect benefits resulting from forests to the mountains, as the plantations and embankments which form the *reboisement* works are too costly ever to yield a direct revenue commensurate with the heavy expenditure incurred in such remote and inaccessible places. If, however, Major Powell's proposed denudation of the Rocky Mountains were to be effected, besides its disastrous indirect results, America would suffer from a greatly curtailed supply of timber to meet the ever-increasing demands of a vast continent, which cannot depend on any adequate supply from abroad. We see that in the McKinley Act the Government of the United States already acknowledges its own short supply by withdrawing all import duties from Canadian timber; and it is for Canada to assure its own future prosperity by establishing a State forest service to prevent the exhaustion of the Canadian forests, now that they are likely to be fully utilized.

Up to the present time, the Forest Department of the United States has been chiefly occupied in collecting forest statistics and encouraging private planting, but what is really required is to induce each State in the Union to establish a practical control of its own still existing forests.

The Americans have recently refused to join in a postal confederation of English-speaking countries, on the ground that they are now to a large extent German-speaking as well; it is a pity, therefore, that they do not listen to the warnings of the German forester, Dr. Mayer, who has studied the forests of the Rocky Mountains and has given the last word of German scientific opinion on the utter absence of a State forest policy in the United States, in his recently published work on the forest trees of North America. W. R. FISHER.

Cooper's Hill College.

Throwing-Sticks and Canoes in New Guinea.

I HAVE just received here my copy of the February number of vol. xix. of the Journal of the Anthropological Institute, in which I have read, with the greatest interest and appreciation, the long and valuable account of the western tribe of Torres Strait, by Prof. Haddon. With regard to the throwing-sticks, of which, on p. 332, he says, "the heavy spears of South-east New Guinea are hurled by a throwing-stick which differs from any Australian implement," I think some error must have been made by his informant. I never saw a throwing-stick in existence, or in use, during my three years' residence in the country, either in the interior, along the south-eastern peninsula, in the Louisiade Archipelago, or on the northern coast as far as Mitre Rock. If these implements do exist on the southern side, they must be very rare. The first spear-thrower from New Guinea brought to England, as far as I am aware, was, nevertheless, the one brought home by me in 1888, which is now in the British Museum. It came, however, from the German possessions on the north-east coast, either from Finch-haven, or from the Augusta River, if I recollect correctly, and was given to me in Cooktown.

In the same paper, on p. 384, occurs this passage with regard to canoes:—"I was much puzzled when I first went to Torres Straits by occasionally seeing a canoe with a single outrigger. I afterwards found that it belonged to a Kanaker from Ware [? Mare], one of the New Hebrides, residing at Mabuiag, and that he had outrigged a native canoe according to the fashion of his own people. When I was at Mabuiag, some natives of that island were fitting up a canoe in imitation of this one, and with a single outrigger. Here a foreign custom is being imitated." The bulk of the large canoes seen on the south-eastern coast at Motu-Motu, Port Moresby, Kerepunu, and in Milne Gulf, have no outriggers at all; while along the coast in small canoes, and in both large and small in the Louisiade Archipelago, the single outrigger is the prevailing form. It is the canoe indigenous to the region, and is undoubtedly not an introduced or imitated custom. The single outrigger in Torres Strait may be an imitation, but it is also a true New Guinea model.

HENRY O. FORBES.

Canterbury Museum, Christchurch, New Zealand, October 29, 1890.

Pectination.

I HAVE been somewhat disappointed to find that no one can suggest a better explanation of the pectination of birds' claws than that which I gave in NATURE of December 4, 1890 (p. 103). As this is the case, however, perhaps I may be permitted to add a remark to what I then said. It has been pointed out to me by a friend that the lateral position of the serration is not so disadvantageous for scratching purposes as I had imagined. While gladly admitting this—which removes a difficulty from the explanation—I still think that my observations must not be taken as conclusive.

It would be most useful and interesting if an observer could be found to give time and attention to representatives of the different orders of birds which possess this peculiarity.

E. B. TITCHENER.

Inselstrasse 13, Leipzig, January 7.

The Flight of Larks.

THE extraordinary flight of larks to which the Rev. E. C. Spicer refers was observed at Bournemouth. The birds appeared to come across the Channel in thousands, and in a few days had entirely disappeared. There were certainly some fieldfares among them. ALFRED W. BENNETT.

PROFESSOR VIRCHOW ON THE CONSUMPTION CURE.[1]

THE important communication made by the renowned German pathologist at the last meeting of the Berlin Medical Society is a severe shock to the opinions of those who expect that Koch's mysterious lymph will prove applicable in every case of consumption. Prof. Virchow gives the result of his observations on twenty-one cases that have died, after treatment with the lymph, up to the end of December. Since then, six or seven other cases have come under his notice, but have not yet been completely examined. Of the twenty-one cases, sixteen were phthisical. The remaining five included a case of joint tuberculosis; a case in which lung tuberculosis was accompanied with carcinoma of the pancreas; another had empyema; the next had pernicious anæmia, slight changes in the lungs, and tuberculous pleuritis; and, lastly, comes a case of tubercular inflammation of the arachnoid.

It appears, from an examination of these cases, that the lymph has an action on tuberculosis of internal organs similar to that which it has already been seen to exert on external portions of the body similarly affected. The signs of an intense irritation, such as redness and swelling, are very generally to be met with. An excellent example of this action is afforded by the above-mentioned

[1] Reported in the *Berliner klinische Wochenschrift*, January 12, 1890, p. 41.

case of inflammation of the arachnoid. Death occurred after the fourth injection, and Prof. Virchow has never seen so intense a hyperæmia of the pia mater and brain as this case presented. After careful examination no regressive changes could be found in the tubercular tissues.

The inflammatory changes met with in the various cases were not confined to a simple hyperæmia, which might possibly be regarded as of a transitory nature, but tissue changes which promised to be of a more lasting nature were also to be met with. The lymph glands near the affected parts, for instance, were found to be greatly enlarged. The increase in size seems due to a rapid multiplication of the cells in the medullary part of the gland—a change which is characteristic of acute irritations. This is probably connected with the increase in the number of white blood-corpuscles that has frequently been found to follow lymph injections, and this, again, with the frequent infiltration by leucocytes of affected parts and their surrounding tissues.

The changes produced in the lungs themselves belong to two widely different categories. Firstly, comes "caseous hepatization." That this can be actually caused by the injections is rendered highly probable by a very striking case, in which infiltration only commenced after the treatment had ceased, and led to a caseous hepatization of almost unique extent. Six injections had been made on this patient, of which the last was made four weeks before his death. Secondly, a "catarrhal pneumonia" is met with, sometimes alone, sometimes accompanied by the first-mentioned change. This form of pneumonia differs from ordinary catarrhal pneumonia in that it seems to lead to a rapid destruction of the lung-parenchyma, and a sort of cavity formation.

The most important conclusion that Prof. Virchow puts forward is that the formation of new tubercles which has been met with in many of these fatal cases must be ascribed with great probability to the action of the lymph itself.

The appearance of new tubercles has already been observed in lupus and tuberculosis of the larynx. Hitherto it has been asserted that the changes in question were merely due to the action of the lymph on tubercular material latent in the apparently healthy tissues. This view appears to be no longer tenable, at any rate as a general explanation. On serous membranes, which Virchow has always regarded as being best fitted for the observation of the early stages of tuberculosis, perfectly new submiliary tubercles have been found, under conditions which make it scarcely probable that they dated from an earlier stage of the disease. All these tubercles were perfectly intact, even in cases in which the injections had been made several weeks before. There was nothing to support the suggestion that these tubercles had been in any way affected or harmed by the action of the lymph.

How can this outbreak of new tubercles be explained? In a phthisical case which terminated fatally, four small tubercles, surrounded by a zone of well-marked hyperæmia, were found situated on a part of the pericardium that could in no way come into contact with the lungs. In this case a direct infection was impossible, and we must suppose that, owing to the action of the lymph in breaking down the tubercular masses in the lungs, tubercle bacilli were thrown into the circulation, and thus reached the pericardium, where they succeeded in producing a metastatic infection.

In consequence of these and other similar observations, Prof. Virchow comes to the conclusion that the lymph should not be employed in cases in which one would expect some difficulty in excreting the tubercular matter set free by the treatment.

In forming an opinion as to the clinical bearing of these *post-mortem* appearances, it must be borne in mind that most, if not all, of these fatal cases were already in an advanced stage before they came under treatment; and, from the practical point of view, Virchow's work merely adds to the evidence that is gradually accumulating in the Berlin clinics, of the unsuitability of Koch's lymph for advanced cases, at all events with the present methods of administration.

For other considerations arise besides that of the stage of the disease. Thus I have good reason for believing that Koch's treatment of consumption has been less successful at the Charité (in which hospital Virchow's twenty-one cases have occurred) than in the other hospitals and clinics of Berlin. It would be interesting to determine whether any difference in the details of the treatment at the various hospitals could help to explain the difference in the results. The quantities of lymph employed and the frequency of the injections are by no means uniform in the various hospitals. For example, the Charité and the Friederichshain appear to stand at the opposite ends of the scale in these respects. For the following details respecting these hospitals I am indebted to a friend, who during the last month has been studying the results in the various clinics. At the Charité the injections appear to be administered more frequently and with a more rapid increase in the size of the doses than is the custom in the Friedrichshain Hospital. Further, the largest dose administered to a patient at Friedrichshain seems almost always below that given at the Charité, whilst the average dose given at the latter hospital also seems generally larger. Naturally, it would be unwise to draw definite conclusions until the details of such a comparison have been thoroughly investigated, but whatever the explanation may be, I have good reasons for asserting that the results obtained at Friedrichshain have been far more favourable than those obtained at the Charité. Not only do the milder cases seem to have made better progress at the former hospital, but the severer cases have less often had a fatal termination.

It would thus appear as if the dosage alone has a considerable influence upon the results obtained, even in the advanced cases which alone are the subject of Prof. Virchow's animadversion. E. H. HANKIN.

THE RESEARCHES OF DR. R. KŒNIG ON THE PHYSICAL BASIS OF MUSICAL SOUNDS.[1]

III.

A FINAL proof, if such were needed, is afforded by an experiment, which, though of a striking character, will not necessarily be heard by all persons present, being only well heard by those who sit in certain positions. If a shrill tuning-fork is excited by a blow of the steel mallet, and held opposite a flat wall, part of the waves which it emits strike on the surface, and are reflected. This reflected system of waves, as it passes out into the room, interferes with the direct system. As a result, if the fork, held in the hand be moved toward the wall or from it, a series of maxima and minima of sound will successively reach an ear situated in space at any point near the line of motion, and will be heard as a series of beats; the rapidity with which they succeed one another being proportional to the velocity of the movement of the fork. The fork Dr. Kœnig is using is ut_6, which gives well-marked beats, slow when he moves his arm slowly, quick when he moves it quickly. There are limits to the speed at which the human arm can be moved, and the quickest speed that he can give to his fails to make the beats blend to a tone. But if he will take sol_6, vibrating 1½ times as fast, and strike it, and move it away from the wall with the fastest speed that his arm will permit, the

[1] By Prof. Silvanus P. Thompson. (Communicated by the author having been read to the Physical Society of London, May 16, 1890.) Continued from p. 227.

beats blend into a short low growl, a non-uniform tone of low pitch, but still having true continuity.

This first portion of my account of Dr. Kœnig's researches may then be summarized by saying that in all circumstances where beats, either natural or artificial, can be produced with sufficient rapidity, they blend to form a beat-tone of a pitch corresponding to their frequency.

I now pass to the further part of the researches of Dr. Kœnig which relates to the timbre of sounds. Prior to the researches of Dr. Kœnig, it had been supposed that in the reception by the ear of sounds of complex timbre the ear took no account of, and indeed was incapable of perceiving, any differences in phase in the constituent partial tones. For example, in the case of a note and its octave sounded together, it was supposed and believed that the sensation in the ear, when the difference in phase of the two components was equivalent to one-half of the more rapid wave, was the same as when that difference of phase was one-quarter, or three-quarters, or zero. I had myself, in the year 1876, when studying some of the phenomena of binaural audition, shown reason for holding that the ear does nevertheless take cognizance of such differences of phase. Moreover, the peculiar rolling or revolving effect to be noticed in slow beats is a proof that the ear perceives some difference due to difference of phase. Dr. Kœnig is, however, the first to put this matter on a distinct basis of observations. That such differences of phase occur in the tones of musical instruments is certain: they arise inevitably in every case where the sounds of subdivision are such that they do not agree rigidly with the theoretical harmonics. Fig. 5 depicts a graphic record taken by Dr. Kœnig from a vibrating steel wire, in which a note and its octave had been simultaneously excited. The two sounds were scarcely perceptibly different from their true interval, but the higher note was just sufficiently sharper than the true harmonic octave to gain about one wave in 180. The graphic trace has in Fig. 5 been split up into 5 pieces to facilitate insertion in the text. It will be seen that as the phase gradually changes the form of the waves undergoes a slow change from wave to wave. Now, it is usually assumed that in the vibrations of symmetrical systems, such as stretched cords and open columns of air, the sounds of subdivision agree with the theoretical harmonics. For example, it is assumed that when a stretched string breaks up into a nodal vibration of four parts, each of a quarter its length, the vibration is precisely four times as rapid as the fundamental vibration of the string as a whole. This would be true if the string were absolutely uniform, homogeneous, and devoid of rigidity. Strings never are so; and even if uniform and homogeneous, seeing that the rigidity of a string has the effect of making a short piece stiffer in proportion than a long piece, cannot emit true harmonics as the sounds of subdivision. In horns and open organ-pipes the width of the column

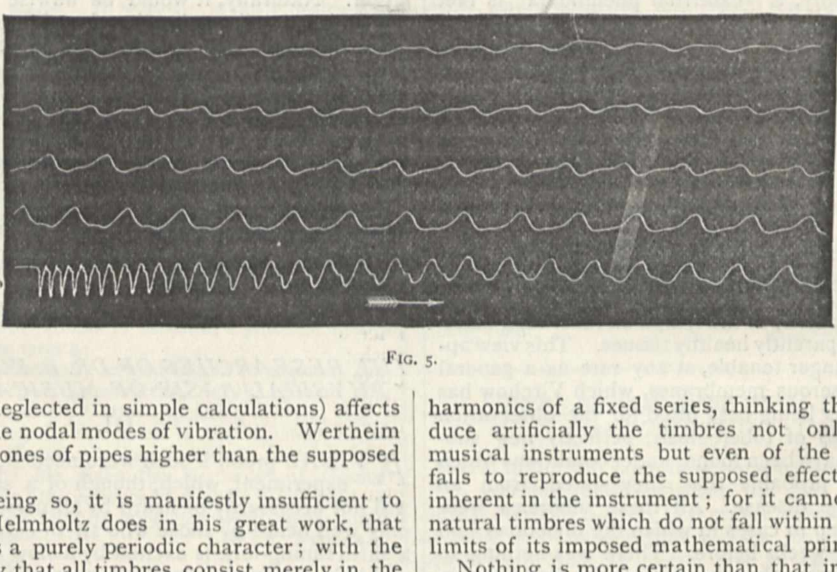


FIG. 5.

(which is usually neglected in simple calculations) affects the frequency of the nodal modes of vibration. Wertheim found the partial tones of pipes higher than the supposed harmonics.

These things being so, it is manifestly insufficient to assume, as von Helmholtz does in his great work, that all timbres possess a purely periodic character; with the necessary corollary that all timbres consist merely in the presence, with greater or less intensity, of one or more members of a series of higher tones corresponding to the terms of a Fourier series of harmonics. When, therefore, following ideas based on this assumption, von Helmholtz constructs a series of resonators, accurately tuned to correspond to the terms of a Fourier series (the first being tuned to some fundamental tone, the second to one of a frequency exactly twice as great, the third to a frequency exactly three times, and so forth), and applies such resonators to analyze the timbres of various musical and vocal sounds, he is trying to make his resonators pick up things which in many cases do not exist—upper partial tones which are exact harmonics. If they are not exact harmonics, even though they exist, his tuned resonator does not hear them, or only hears them imperfectly, and he is thereby led into an erroneous appreciation of the sound under examination.

Further, when in pursuance of this dominant idea he constructs a system of electro-magnetic tuning-forks, accurately tuned to give forth the true mathematical harmonics of a fixed series, thinking therewith to reproduce artificially the timbres not only of the various musical instruments but even of the vowel sounds, he fails to reproduce the supposed effects. The failure is inherent in the instrument; for it cannot reproduce those natural timbres which do not fall within the circumscribed limits of its imposed mathematical principle.

Nothing is more certain than that in the tones of instruments, particularly in those of such instruments as the harp and the pianoforte, in which, the impulse, once given, is not sustained, the relations between the component partial tones are continually changing, both in relative intensity and in phase. The wavelets, as they follow one another, are ever changing their forms: in other words, the motions are not truly periodic—their main forms may recur, but with modifications ever changing.

To estimate the part played in such phenomena by mere differences of phase—to evaluate, in fact, the influence of phase of the constituents upon the integral effect of a compound sound—Dr. Kœnig had recourse to the *wave-siren*, an earlier invention of his own, and of which the wave-disks which have already been shown are examples.

In the first place, Dr. Kœnig proceeded synthetically to construct the wave-forms for tones consisting of the resultant of a set of pure harmonics of gradually decreasing intensity. The curves of these, up to the tenth member of the series, were carefully compounded graphically: first with zero difference of phase, then with all the upper members shifted on one quarter, then with a difference of a half-wave, then with a difference of three-quarters. The results are shown in the top line of curves in Fig. 6, wherein it will be noticed that the curve for difference of phase = $\frac{1}{2}$ is like that for zero difference, but reversed, left for right; and that the curve for difference of phase = $\frac{3}{4}$ is like that for difference = $\frac{1}{4}$, but inverted. Now, according to von Helmholtz, the sounds of all these four curves should be precisely alike, in spite of their differences of form and position. To test the matter, these care-

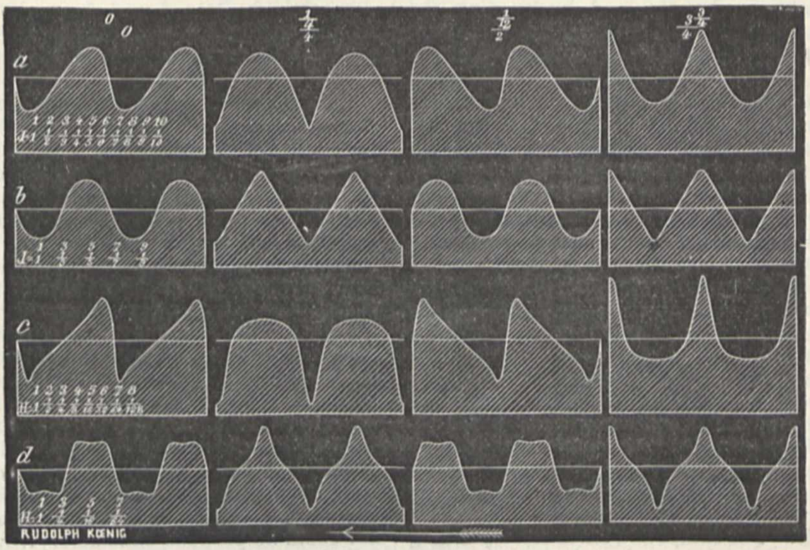


FIG. 6.

fully-plotted curves were set out upon the circumference of a cylindrical band of thin metal, the edge being then cut away, leaving the unshaded portion, the curve being repeated half a dozen times, and meeting itself after passing round the circumference. For convenience, the four curves to be compared are set out upon the separate rims of two such metallic cylindrical hoops, which are mounted

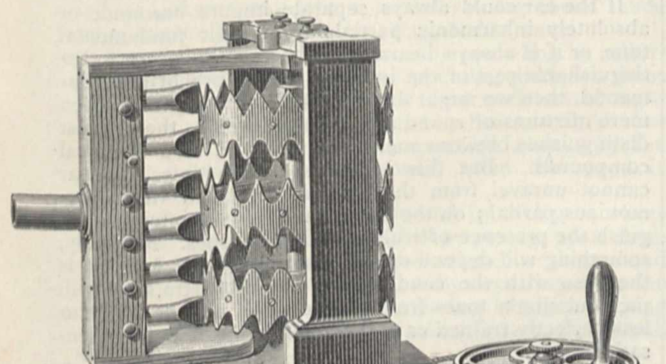


FIG. 7.

upon one axis, to which a rapid motion of rotation can be imparted, as shown in Fig. 7. Against the dentellated edges of these rims, wind can be blown through narrow slits connected to the wind-chamber of an organ-table. In the apparatus (Fig. 7) the four curves in question are the four lowest of the set of six. It will be obvious that, as these curves pass in front of the slits from which wind issues, the maximum displacement of air will result when the slit is least covered, or when the point of greatest depression of the curve crosses the front of the slit. The negative ordinates of the curve correspond, therefore, approximately to condensations. Air is now being supplied to the slits; and when I open one or other of the valves which control the air-passages, you hear one or other of the sounds. It must be audible to everyone present that the sound is louder and more forcible with a difference of phase of $\frac{1}{4}$ than in any other case, that produced with $\frac{3}{4}$ difference being gentle and soft in tone, whilst the curves of phase 0 and $\frac{1}{2}$ yield tones of intermediate quality. Dr. Kœnig found that, if he merely combined together in various phases a note and its octave (which was indeed the instance examined by me binaurally in 1876), the loudest resultant sound is given when the phase-difference of the combination is $\frac{1}{4}$, and the mildest when it is $\frac{3}{4}$.

Returning to Fig. 6, in the second line are shown the curves which result from the superposition of the odd members only of a harmonic series of decreasing amplitude. On comparing together the curves of the four separate phases, it is seen that the form is identical for phases 0 and $\frac{1}{2}$, which show rounded waves, whilst for phases $\frac{1}{4}$ and $\frac{3}{4}$ the forms are also identical, but with sharply angular outline. These two varieties of curve are set out on the two edges of the highest metallic circumference in the apparatus depicted in Fig. 7. The angular waves are found to yield a louder and more strident tone than the rounded waves, though, according to von Helmholtz, their tones should be alike.

A much more elaborate form of compound wave-siren was constructed by Dr. Kœnig for the synthetic study of these phase-relations. Upon a single axis, one behind the other is mounted a series of 16 brass disks, cut at their edges into sinusoidal wave-forms. These represent a harmonic series of 16 members of decreasing amplitude, there being just 16 times as many small sinuosities on the edge of the largest disk as there are of large sinuosities on that of the smallest disk. A photograph of the apparatus is now thrown upon the screen. It is described fully by Dr. Kœnig in his volume "Quelques Expériences," and was figured and described in NATURE, vol. xxvi. p. 277. Against the edge of each of the 16 wave-disks wind can be separately blown through a slit. This instrument therefore furnishes a fundamental sound with its first fifteen pure harmonics. It is clear that any desired combination can be obtained by opening the appropriate stops on the wind-chest; and there are ingenious arrangements to vary the phases of any of the separate tones by shifting the positions of the slits. The following are the chief results obtained with this instrument. If we first take simply the fundamental tone and its octave together, the total resultant sound has the greatest intensity when the difference of phase $\delta = \frac{1}{4}$ (*i.e.* when the maximum displacement of air occurs at the same instant for both waves); and at the same time the whole character of the sound becomes somewhat graver, as if the fundamental tone predominated more than in other phases. The intensity is least when $\delta = \frac{3}{4}$. If, however, attention is concentrated on the octave note while the phase is changed, its intensity seems about the same for $\delta = \frac{1}{4}$ as for $\delta = \frac{3}{4}$, but weaker in all other positions. The compound tones formed only of odd members of the series have always more power and brilliancy of tone for phase differences of $\frac{1}{4}$ and $\frac{3}{4}$, than for o and $\frac{1}{2}$; but the quality for $\frac{1}{4}$ is always the same as for $\frac{3}{4}$, and the quality for o is always the same as for $\frac{1}{2}$. This corresponds to the peculiarity of the corresponding wave-form, of which the fourth line of curves in Fig. 6 is an example. For compound tones corresponding to the whole series, odd and even, there is, in every case, minimum intensity, brilliancy, and stridence with $\delta = \frac{3}{4}$, and maximum with $\delta = \frac{1}{4}$. Inspection of the first and third lines of curves in Fig. 6 shows that in these wave-forms that phase which is the most forcible is that in which the maximum displacement, and resulting condensation, is sudden and brief.

Observing that wave-forms in which the waves are asymmetrical—steeper on one side than on the other—are produced as the resultant of a whole series of compounded partial tones, it occurred to Dr. Kœnig to produce from a perfect and symmetrical sinusoidal wave-curve a complex sound by the very simple device of turning into an oblique position the slit through which the wind was blown against it. In Fig. 8 is drawn a simple sym-

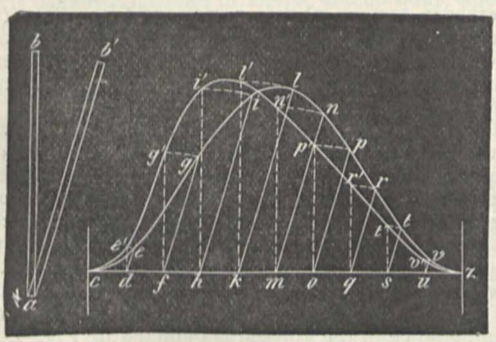


FIG. 8.

metrical wave-form, *eglnprtv*. If a series of such wave-forms is passed in front of a vertical slit, such as *ab*, a perfectly simple tone, devoid of upper partials, is heard. But by inclining the slit, as at *ab'*, the same effect is produced as if the wave-form had been changed to the oblique outline *e'g'l'n'p'r't'v'*, the slit all the while remaining upright. But this oblique form is precisely like that obtained as resultant of a decreasing series of partial tones (Fig. 6, *a*). If the slit be inclined in the same direction as the forward movement of the waves, the quality produced is the same as if all the partial tones coincided at their origin, or with $\delta = 0$; while if inclined in the opposite direction the quality is that corresponding to $\delta = \frac{1}{2}$. It is easy to examine whether the change of phase produces any effect on the sound. Before you is rotating a simple wave-disk, and air is being blown across its edge through a slit. Dr. Kœnig will now tilt the slit alternately backward and forward. On tilting the slit forward to give $\delta = 0$, you hear a purer and more perfect sound; and on tilting it back, giving $\delta = \frac{1}{2}$, a sound that is more nasal and forcible.

All the preceding experiments agree then in showing that differences of phase do produce a distinct effect upon the quality of compound tones: what then must we say as to the effect on the timbre of the presence of upper partial tones or sounds of subdivision that do not agree with any of the true harmonics? A mistuned harmonic—if the term is permissible—may be looked upon as a harmonic which is undergoing continual change of phase. The mistuned octave which yielded the graphic curve in Fig. 5 is a case in point. The wavelets are continually changing their form. It is certain that in a very large number of musical sounds, instrumental and vocal, such is the case.

It was whilst experimenting with his large compound wave-siren that Dr. Kœnig was struck by the circumstance that under no conditions, and by no combination of pure harmonics in any proportion of intensity or phase, could he reproduce any really strident timbres of sound, like those of harmonium reeds, trumpets, and the like; nor could he produce satisfactory vowel qualities of tone. Still less can these be produced satisfactorily by von Helmholtz's apparatus with electro-magnetic tuning-forks, in which there is no control over the phases of the components. The question was therefore ripe for investigation whether for the production of that which the ear can recognize as a *timbre*, a definite unitary quality of tone, it was necessary to suppose that all the successive wavelets should be of similar form. Or, if the forms of the successive wavelets are continually changing, is it possible for the ear still to grasp the result as a unitary sensation?

If the ear could always separate impure harmonic or absolutely inharmonic partials from their fundamental tone, or if it always heard pure harmonics as an indistinguishable part of the unity of the timbre of a fundamental, then we might draw a hard and fast line between mere mixtures of sound and timbres, even as the chemist distinguishes between mere mixtures and true chemical compounds. But this is not so: sometimes the ear cannot unravel from the integral sensation the inharmonious partial; on the other hand, it can often distinguish the presence of truly harmonious ones. Naturally, something will depend on the training of the ear; as is the case with the conductor of an orchestra, who will pick out single tones from a mixture of sounds which to less perfectly trained ears may blend into a unitary sensation.

Dr. Kœnig accordingly determined to make at least an attempt to determine synthetically how far the ear can so act, by building up specific combinations of perturbed harmonics or inharmonic partials, giving rise to waves that are multiform, as distinguished from the uniform waves of a true periodic motion. The wave-siren presented a means of carrying this attempt to a result. On the table before me lie a number of wave-disks constructed with this aim. This will be successively placed upon the whirling table, and sounded: but I must warn you that the proper effects will only be perceived by those who are near the apparatus, and in front of it.

Upon the edge of the first of the series there has been cut a curve graphically compounded of 24 waves as a fundamental, together with a set of four perturbed harmonics of equal intensity. The first harmonic consists of 49 waves (2 × 24 plus 1); the second of 75 waves

(3 × 24 plus 3); the third of 101 (4 × 24 plus 5); the fourth of 127 (5 × 24 plus 7). The resulting curve possesses 24 waves, no two of them alike in form, and some highly irregular in contour. The effect of blowing air through a slit against this disk is to produce a disagreeable sound, quite lacking in unitary character, and indeed suggesting intermittence.

The second wave-disk is constructed with the same perturbed harmonics, but with their amplitudes diminishing in order. This disk produces similar effects, but with more approach to a unitary character.

In the third disk there are also 24 fundamental waves, but there are no harmonics of the lower terms, the superposed ripples being perturbed harmonics of the fifth, sixth, and seventh orders. Their numbers are 6 × 24 plus 6; 7 × 24 plus 7; and 8 × 24 plus 8; being, in fact, three harmonics of a fundamental 25. This disk gives a distinctly dual sort of sound; for the ear hears the fundamental quite separate from the higher tones, which seem in themselves to blend to a unitary effect. There is also an intermittence corresponding to each revolution of the disk, like a beat.

The fourth disk resembles the preceding; but the gap between the fundamental and the three perturbed harmonics has been filled by the addition of three true harmonics. This disk is the first in this research which gives a real timbre, though it is a peculiar one: it preserves, however, a unitary character, even when the slit is tilted in either direction. The 24 waves in this disk all rake forward like the teeth of a circular saw, but with multiform ripples upon them. The quality of tone becomes more crisp when the slit is tilted so as to slope across the teeth, and more smooth when in the reverse direction.

The fifth disk, which is larger, has 40 waves at its edge; these are cut with curves of all sorts, taken hap-hazard from various combinations of pure harmonics in all sorts of proportions and varieties, no two being alike, there maxima and minima of the separate waves being neith isochronous nor of equal amplitude. This disk gives an entirely unmusical effect, amid which a fundamental tone is heard, accompanied by a sort of rattling sound made up of intermittent and barely recognizable tones.

The sixth disk is derived from the preceding by selecting eight only of the waves, and repeatiug them five times around the periphery. In this case each set of eight acts as a single long curve, giving beats, with a slow rotation, and a low tone (accompanied always by the rattling mixture of higher tones) when the speed is increased.

The seventh disk was constructed by taking 24 waves of perfect sinusoidal form, and superposing upon them a series of small ripples of miscellaneous shapes and irregular sizes, but without essentially departing from the main outline. This disk gives a timbre in which nothing can be separated from the fundamental tone, either with vertical or tilted slit.

The eighth and last disk consists of another set of 24 perfect waves, from the sides of which irregular ripples have been carved away by hand, with the file, leaving, however, the summits and the deepest parts of the hollows untouched, so that the maxima and minima are isochronous and of equal amplitude. This disk gives also a definite timbre of its own, a little raucous in quality, but still distinctly having a musical unity about it.

We have every reason, therefore, to conclude that the ear will recognize as possessing true musical quality, as a timbre, combinations in which the constituents of the sound vary in their relative intensity and phase from wave to wave.

What, then, is *a timbre?* Dr. Kœnig would be the first to recognize that these last experiments, though of deepest interest, do not afford a final answer to the question. We may not yet be in a position to frame a new definition as to what constitutes a timbre, but we may at least conclude that, whenever that definition can be framed, it will at least include several varieties, including the non-periodic kinds with multiform waves, as well as those that are truly periodic with uniform waves. We must not on that account, however, rush to the conclusion that the theory of von Helmholtz as to the nature of timbre has been overthrown. The corrections introduced into lunar theory by Hansen and Newcomb have not overturned the splendid generalizations of Newton. What we can and must confess is that we now know that the acoustic theory of von Helmholtz is, like the lunar theory of Newton, correct only as a first approximation. It has been the distinctive merit of Dr. Kœnig to indicate to us the magnitude of the correcting terms, and to supply us not only with a rich store of experimental facts but with the means of prosecuting the research synthetically beyond the point to which he himself has attained.

In thanking Dr. Kœnig for the courtesy which he has shown to this Society in bringing over his apparatus and in demonstrating its use to us, we must join in congratulating him on the patience, perspicacity, and skill with which he has carried out his researches. We know that his exceptional abilities as experimentalist and constructor have done more than those of any other investigator to make the science of experimental acoustics what it is to-day; and we must unite in wishing him long life and prosperity to complete the great work on which already he has advanced so far.

THE GEOLOGY OF ROUND ISLAND.

BOTANISTS have been a little perplexed as to the exact geological age of some of the islands in the Indian Ocean, and the current statements on the subject are by no means accordant. Any exact information on the subject seems, therefore, worth placing on record.

Round Island is a minute island, about two miles in diameter, which lies north-east of Mauritius, and about 13 miles distant. It was visited last November by Mr. William Scott, Assistant to the Director of Forests and Botanical Gardens, Mauritius, accompanied by Surgeon H. H. Johnston.

There is only one point where landing can be effected in calm weather; the end of November was therefore chosen for the visit as being the best season for landing. Unfortunately, the season at this time was very dry, so that the whole of the vegetation was in a dormant state, and little could be done in the way of procuring good specimens.

"The only trees," Mr. Scott writes, "of any size to be found on the island, are the Palms:—*Latania Loddigesii*, *Hyophorbe amaricaulis*, *Dictyosperma alba*, var. *aurea*, and the screw-pine *Pandanus Vandermeeschii.* These trees look stunted, and grow in clumps mixed up together where any root-hold is to be found. There were only at that time two or three grasses to be found, and these were in a very dry state. One or two Passifloras [probably introduced] and *Asclepiadaceæ* were also found. On these two latter, the wild goats which inhabit the island in hundreds, appear to exist."

Mr. Scott made a very careful collection of the rocks composing the island. His specimens were sent to Kew and were submitted to Prof. Judd, F.R.S., who very kindly examined them. He furnished me with the following report, which he has kindly allowed me to publish. W. T. THISELTON DYER.

Royal Gardens, Kew, December 4.

Science Schools, South Kensington, S.W.,
September 29.

MY DEAR DYER,—Immediately upon my return to town I have, as I promised you, examined the specimens from Round Island, with the notes on the same by Mr. Scott. My conclusions are as follows:—

The rocks of the island appear to be entirely of organic or volcanic origin.

The lower part of the island consists of a limestone made up of shell and coral (?) detritus, cemented into a hard and crystalline rock (see specimens 1, 3, 15). Masses of this rock of greater hardness than usual seem to have resisted denudation, and stand up as pinnacles among the overlying stratified tuffs (specimen 14). Fissures in the various rocks are filled with a stalagmitic deposit of calcic carbonate (specimen 8). But the great mass of the island would appear to be made up of stratified *palagonite tuffs*, some coarse-grained, others very fine-grained. These palagonite tuffs, which closely resemble the similar rocks in Sicily and Iceland, are very beautiful and interesting varieties; and, besides the hydrous basic glass known as palagonite, contain various beautiful zeolites and other minerals (specimens 4, 5, 6, 7, 9, 10, 11, 12).

The lavas associated with these tuffs appear to occur both as ejected blocks and in lava-currents, and consist of a highly scoriaceous basalt rich in olivine (specimens 2 and 13).

These are the general facts concerning the structure of the island which are revealed by a general examination of the specimens with Mr. Scott's interesting notes.

I return these last with this letter. The specimens I retain for the present, as some among them will, I think, repay a minuter study than I have yet been able to afford time for.

JOHN W. JUDD.

NOTES.

THE Medals and Funds to be given at the anniversary meeting of the Geological Society of London on February 20 have been awarded by the Council as follows: the Wollaston Medal to Prof. J. W. Judd, F.R.S.; the Murchison Medal to Prof. W. C. Brögger, of Christiania; the Lyell Medal to Prof. T. McKenny Hughes, F.R.S.; and the Bigsby Medal to Dr. G. M. Dawson; the balance of the Wollaston Fund to Mr. R. Lydekker; that of the Murchison Fund to Mr. R. Baron; and portions of the Lyell Fund to Messrs. C. J. Forsyth Major and G. W. Lamplugh.

AT the meeting of the Institution of Civil Engineers on Tuesday, M. Carnot, President of the French Republic, was elected an honorary member.

THE forty-fourth annual general meeting of the Institution of Mechanical Engineers will be held on Thursday evening, January 29, and Friday evening, the 30th, at 25 Great George Street, Westminster. The chair will be taken by the President, Mr. Joseph Tomlinson, at half-past seven p.m. on each evening. After the presentation of the annual report, and the transaction of other business, the following papers will be read and discussed, as far as time permits:—On some different forms of gas furnaces, by Mr. Bernard Dawson, of Malvern; on the mechanical treatment of moulding sand, by Mr. Walter Bagshaw, of Batley; fourth report of the research committee on friction: experiments on the friction of a pivot bearing.

THE Royal Microscopical Society will hold its annual meeting on Wednesday evening, the 21st inst., at 8 o'clock. The President will deliver an address.

THE annual general meeting of the Royal Meteorological Society will be held at 25 Great George Street, Westminster, on Wednesday, the 21st inst., at 8.15 p.m. It will be preceded by an ordinary meeting, beginning at 7 p.m., at which the following papers will be read:—Note on a peculiar development of cirrus cloud observed in Southern Switzerland, by Mr. Robert H. Scott, F.R.S.; and some remarks on dew, by Colonel W. F Badgley, F.R.Met.Soc.

THE Council of the Royal Meteorological Society have arranged to hold at 25 Great George Street, Westminster, from March 17 to 20, an Exhibition of rain gauges, evaporation gauges, percolation gauges, and kindred instruments. The Exhibition Committee invite co-operation in this undertaking. They will also be glad to show any new meteorological instruments or apparatus invented, or first constructed, since last March; as well as photographs and drawings possessing meteorological interest. Anyone willing to co-operate in the proposed Exhibition should furnish Mr. William Marriott, the Secretary, not later than February 10, with a list of the articles he will be able to contribute, and an estimate of the space they will require.

THE Sanitary Institute has made arrangements for a course of sixteen lectures for the special instruction of those who may wish to obtain knowledge of the duties of sanitary officers. These lectures, which will be a continuation of previous courses, will be delivered at the Parkes Museum, and will be illustrated with diagrams, drawings, and models. The first lecture will be given on January 30 by Sir Douglas Galton, who will deal with ventilation, warming, and lighting. Among the other lecturers will be Mr. H. Law, Dr. Louis Parkes, and Prof. W. H. Corfield.

DR. SYMES THOMPSON will deliver at Gresham College, on January 20 and the three following days, a course of four lectures on the preservation of health. He will deal with questions relating to healthy homes, healthy schools, and the early detection and prevention of disease.

MR. A. SIDNEY OLLIFF, late assistant in the Museum, Sydney, has been appointed to the newly-instituted office of Government Entomologist in the Department of Agriculture, New South Wales. His duties will be chiefly the study of insects affecting fruits and crops, whether injurious or beneficial, and publishing reports on the results for the information of farmers and horticulturists. According to the latest news as to the new insect pest, Mr. Olliff will not lack employment.

M. PATOUILLARD has been elected President, and MM. Prillieux and de Seynes, Vice-Presidents, of the Société Mycologique de France.

THE death is announced of M. Clavaud, Professor of Botany at Bordeaux, author of the "Flora de la Gironde," of which two parts only have appeared, embracing the *Thalamifloræ* and the *Calycifloræ*. The work is characterized by its beautiful plates, and by the attempts to place on a scientific basis the genetic relationship of the various species with one another.

MR. GEORGE W. ORMEROD, of Teignmouth, died on January 6, at the age of eighty. He had been a member of the Geological Society of London for fifty-eight years, and geologists owe much to him for his classified index to the *Quarterly Journal* and other publications.

ACCORDING to a telegram from Rusk, Texas, two sharp earthquake shocks were felt there on January 8. Chimneys were thrown to the ground, and people awakened by the violence of the oscillations.

AT the meeting of the French Meteorological Society on December 2, M. Angot communicated the results of comparisons of the pressure and temperature observations at the Eiffel Tower during 1889 with the low-level stations. The night maxima and minima of pressure are less marked on the Tower than at the lower levels, as is also the case with mountain observations, and inversely for the day maxima and minima. For individual readings small variable differences were found between the actual pressure at the summit and the pressure calculated from observations at the base. Generally, during rapid falls of the barometer, the true pressure at the summit is lower than the calculated value, and higher when the barometer is rising. The temperature observations will be referred to subsequently. At the meeting of December 16 a discussion took place upon the trustworthiness of aneroid barometers, owing to their not always immediately returning to their original condition after a sudden rise or fall. The balance of opinion was in their favour. M. Doumet-Adanson communicated an account of a tornado at Fourchambault on October 1, 1890. Its sudden appearance there is supposed to be due to one of a series of bounds and rebounds which these meteors are sometimes reported to make. M. Angot was elected President of the Society for the ensuing year.

La Nature of January 3 describes a useful recording barometer brought out by MM. Redier and Meyer. In the upper part of a case with glass front is an aneroid, the elastic cover of which is connected with a metallic slip projecting over rotated paper below. At the end of this slip is a conical ink-holder with perforated point. Three times in the hour this descends to make a dot on the paper, and the dots form a curve of the variations of pressure. The instrument goes eight days without needing attention. For observers who do not want to keep a long record, but merely to compare the variations of the day with those of a few days previous, a recording cylinder with smooth white surface is supplied, on which the record can be wiped out. This number of *La Nature* has also an account of a new steam carriage for ordinary roads, which appears to work satisfactorily.

IN his presidential address to the Queensland Royal Society, delivered on November 22, 1890, Mr. W. Saville-Kent spoke strongly in favour of the establishment of a well-appointed zoological station and marine biological laboratory in Queensland. The best site, he said, would be Thursday Island. Situated in Torres Straits, at a distance of twenty miles only from Cape York Peninsula, with a climate far more temperate than that of the mainland, and serving as a weekly or bi-weekly port of call to various lines of mail-steamers, this island is "a perfect paradise for the naturalist." In it is the central depot of the Torres Straits pearl and pearl-shell and the *bêche-de-mer* fisheries. Mr. Saville-Kent is of opinion that the acquirement of accurate knowledge concerning these products, with the application of approved methods of scientific culture, would very soon immensely increase their export value.

IN the current number of the *Revue Scientifique*, M. Hermann Fol has an interesting paper on what he calls the resemblances between husband and wife. The fact that such resemblances are not uncommon has often been noted, but the usual idea is that when they occur they are to be explained by the influence which husband and wife exert on one another in the course of years. M. Fol, however, maintains that in a large number of cases there is a more or less striking likeness from the beginning; and he draws the conclusion that in such instances the mutual attraction which leads to marriage is due to the qualities the lovers have in common, not to those in which they differ. His attention was first directed to the subject in Nice, which is visited by many newly-married people. He was so struck by the resemblances which he observed, or thought he observed, that he obtained the photographs of 251 couples who were not personally known to him, and in each case carefully noted the appearance of husband and wife. The general results he presents as follows:—

Couples.	Resemblances. Per cent.	Non-resemblances. Per cent.	Total.
Young ...	132 : about 66·66 ...	66 : about 33·33 ...	198
Old ...	38 : ,, 71·70 ...	15 : ,, 28·30 ...	53

THE Russian painter Krilof has for some time been engaged in painting the portraits of typical representatives of the various races included in the Russian Empire. In carrying out his purpose, he has undertaken many long journeys; and he has now a small gallery which ought to be of considerable value from an anthropological as well as from an artistic point of view. In the current number of *Globus* there is a good reproduction of one of these portraits. It represents with much force and insight a Kasak-Kirghiz.

THE director of the central dispensary at Bagdad has sent to *La Nature* a specimen of an edible substance which fell during an abundant shower in the neighbourhood of Merdin and Diarbékir (Turkey in Asia) in August 1890. The rain which accompanied the substance fell over a surface of about ten kilometres in circumference. The inhabitants collected the "manna," and made it into bread, which is said to have been very good and to have been easily digested. The specimen sent to *La Nature* is composed of small *sphérules*; yellowish on the outside, it is white within. Botanists who have examined it say that it belongs to the family of lichens known as *Lecanora esculenta*. According to Decaisne, this lichen, which has been found in Algeria, is most frequently met with on the most arid mountains of Tartary, where it lies among pebbles from which it can be distinguished only by experienced observers. It is also found in the desert of the Kirghizes. The traveller Parrot brought to Europe specimens of a quantity which had fallen in several districts of Persia at the beginning of 1828. He was assured that the ground was covered with the substance to the height of two decimetres, that animals ate it eagerly, and that it was collected by the people. In such cases it is supposed to have been caught up by a waterspout, and carried along by the wind.

MR. E. W. CARLIER writes in the current number of the *Entomologist* that one of the most remarkable features of the entomological record of 1890 was the extraordinary abundance of autumn larvæ. In a garden in Norwich, where he was staying during the month of September, everything was infested with larvæ, even to the ferns, which were in many cases almost entirely stripped of their green parts. The many-coloured larvæ of *Orgyia antiqua* (the common vapourer) were by far the most abundant, proving a perfect nuisance by their curious habit of constantly flinging themselves to the ground, from a wisteria arbour which spans the path. What could induce the insects to act in this manner he was unable to ascertain, as there was nothing but an iron garden-seat and the pebbles of the path to tempt them. This falling was not produced by wind or birds, or any other obvious cause, for, during perfect stillness of all their surroundings, they would fall by dozens upon the unfortunate occupants of the garden-chair. Nor was the habit confined to any particular age or period of the larva's existence, for among those that fell were small, large, and intermediate-sized individuals. Moreover, this habit caused a great mortality among them, for they were no sooner fairly down than they began to make for a white-washed wall which forms one boundary of the path, and attempt to climb up again to the arbour from which they fell. It so happened that many small garden spiders had elected to weave their webs from this wall to the iron framework of the arbour, and as the larvæ came to this part of their journey they often became entangled in the webs, were captured, and preyed upon by the small spiders.

THE *Zoologist* for January contains an interesting paper, by Messrs. W. E. Clarke and E. H. Barrett-Hamilton, on the Irish rat, which is "a melanistic form of *Mus decumanus*." The authors point out that this creature has a peculiar geographical distribution. In Ireland it is widely distributed, and not rare. The only known British localities in which it occurs are in the Outer Hebrides, where it has long been known to the inhabitants, and whence the authors have examined three specimens. It would appear to be quite unknown on the mainland of Britain, where all their endeavours to procure specimens have failed, though they would not be surprised to hear of the occurrence of a melanism of so common a creature as the brown rat. On the continent of Europe the only instance of the occurrence of black varieties of *Mus decumanus* known to the authors is the one recorded by A. Milne-Edwards (*Ann. Sci. Nat.*, 1871, xv. art. 7) for Paris, where, in 1871, it had been known for twenty years in the menagerie of the Museum, and is described as abundant and increasing in numbers.

PROF. J. MARK BALDWIN, writing in *Science* on "infant psychology," points out that this branch of inquiry has the great advantage of offering opportunities for the use of the experimental method. In experimenting on adults, psychologists are confronted with the difficulty that reactions are broken at the centre, and closed again by a conscious voluntary act. The subject hears a sound, identifies it, and presses a button. What goes on between the advent of the incoming nerve process and the discharge of the outgoing nerve process? Something, at any rate, which represents a brain process of great complexity. Anything that fixes this sensori-motor connection, or simplifies the central process, in so far gives greater certainty to the results. For this reason, experiments on reflex reactions are valuable and decisive where similar experiments on voluntary reactions are uncertain and of doubtful value. The fact that the child consciousness is relatively simple, and so offers a field for more fruitful experiment, is seen in the mechanical reactions of an infant to strong stimuli, such as bright colours. Of course, this is the point where originality may be exercised in the devising and executing of experiments. After the subject is a little better developed, new experimentation will be as difficult here as in the other sciences; but at present the simplest phenomena of child life and activity are open to the investigator.

THE "Year-book of Pharmacy" has just been published. It contains abstracts of papers relating to pharmacy, materia medica, and chemistry, contributed to British and foreign journals from July 1, 1889, to June 30, 1890; with the transactions of the British Pharmaceutical Conference at the twenty-seventh annual meeting, held at Leeds in September 1890. The volume has been carefully compiled, and presents a great mass of scientific information. Its utility is greatly increased by a full index.

MESSRS. IMRAY AND SON have issued, for the use of candidates preparing for the Board of Trade examinations, a syllabus of examination in the laws of compass deviation and in the means of compensating it, with explanatory notes and answers, by W. H. Rosser. The paper was written as an appendix to the author's "Deviation of the Compass, considered practically."

MESSRS. DULAU AND CO. have issued a catalogue of zoological and palæontological works which they are offering for sale. The list includes many valuable books.

THE cadmium and magnesium analogues of zinc methide and ethide have been prepared and investigated by Dr. Löhr in the laboratory of Prof. Lothar Meyer at the University of Tübingen, and an account of the work is published in the latest number of *Liebig's Annalen*. The alkyl compounds of cadmium and magnesium have formed the subject of several previous researches, but the results hitherto obtained have been mainly negative, and nothing was known with certainty concerning them. The methide and ethide of cadmium are liquid bodies, spontaneously inflammable when gently warmed. The similar compounds of magnesium are, contrary to expectation, solid substances, which possess the almost unique property of being spontaneously inflammable in carbon dioxide gas, as well as in air, being capable of actually extracting oxygen from its most stable combination with carbon. Cadmium methide was obtained by the following process:—Metallic cadmium, either in filings or pieces of sticks, was placed in a tube closed at one end together with a thin glass bulb containing methyl iodide. The tube was exhausted by the Sprengel pump and sealed. It was then heated to 110° C. for 24 hours. At the end of this time all the methyl iodide had disappeared, and the tube contained a crystalline mixture of cadmium iodide and cadmium methyl iodide, $Cd(CH_3)I$, and gaseous ethane, C_2H_6, at high pressure. After opening the tube so as to permit of the escape of the ethane, the crystalline residue was subjected to dry distillation; when the temperature of the paraffin bath in which the tube was heated reached 260° a small quantity of a liquid distilled over, and was caught in a receiver filled with carbon dioxide. Ten similar experiments were made, and the total product of this liquid was fractionally distilled in a small apparatus also filled with carbon dioxide. By this means the greater part of the admixed methyl iodide was removed, and a heavy residual liquid obtained which was found to consist mainly of cadmium methide, $Cd(CH_3)_2$. Cadmium methide is a clear heavy liquid of most unpleasant odour, violently affecting the respiratory organs, and producing a most persistent nauseous metallic taste in the mouth. It boils at about 105° C. On gently warming it spontaneously inflames, burning with a brilliant sooty flame producing thick clouds, which, according to the amount burnt, take a dark green or a reddish-brown tint. It oxidizes very rapidly to a white mass of ethylate, $Cd(OCH_3)_2$. It reacts most violently with water, producing great heat, and evolving marsh gas. Dilute hydrochloric acid acts similarly, methane being evolved and cadmium chloride formed:

$$Cd(CH_3)_2 + 2H_2O = Cd(OH)_2 + 2CH_4;$$
$$Cd(CH_3)_2 + 2HCl = CdCl_2 + 2CH_4.$$

The liquid solidifies to a white crystalline mass when the vessel containing it is immersed in a freezing mixture. Cadmium ethide is prepared with greater difficulty than the methide. It is a liquid much resembling the methide in properties. Magnesium methide is a solid obtained, mixed with magnesium iodide, when magnesium filings or ribbon are heated in a sealed tube with methyl iodide and acetic ether, methyl iodide alone having no action. It is also obtained mixed with globules of mercury when magnesium is heated with mercury methide in a sealed tube. Its most remarkable properties are its intense action with water, incandescence usually occurring with ignition of the evolved gas; and its spontaneous inflammability in carbon dioxide, the combustion being accompanied by beautiful scintillations. The ethide is a very similar substance.

THE additions to the Zoological Society's Gardens during the past week include two Toque Monkeys (*Macacus pileatus*), a Starred Tortoise (*Testudo stellata*) from Ceylon, presented by Mr. W. J. Bosworth; a Peregrine Falcon (*Falco peregrinus*), British, presented by Mr. A. C. Ionides; a Humboldt's Lagothrix (*Lagothrix humboldti*) from the Upper Amazons, purchased.

OUR ASTRONOMICAL COLUMN.

SPECTROSCOPIC OBSERVATIONS OF SUN-SPOTS.—The *Monthly Notices of the Royal Astronomical Society* for December 1890 contains the main conclusions deduced by the Rev. A. L. Cortie, S.J., from the sun-spot observations made at the Stonyhurst College Observatory in the years 1882-89. The region of the spectrum in which observations have been made is between the lines B and D. The widening of the lines in the sun-spot spectra observed has generally been reckoned in tenths of their normal breadth, and are classified as "widened," "more widened," and "most widened," for comparison among themselves. At South Kensington only the six most widened lines in the spectrum of a sun-spot are recorded, hence the two sets of observations are not easily comparable. The interval 1882–89 has been divided into two periods in the discussion, viz. the disturbed period of solar activity extending from 1882–86, and the quiet period 1886–89.

In the disturbed period only one of the fifty-three iron lines in the region B—D was observed to have a mean widening. During the quiet period, however, many more iron lines appeared among the more widened. In this particular, therefore, Father Cortie's results confirm the conclusion arrived at by Prof. Lockyer in 1880 from a similar discussion. With respect to other substances, the observations show that seven out of the eleven titanium lines in the region studied were very much affected in the spot spectra at both periods, the lines most persistently widened being among the faintest Fraunhofer lines, and among the brighter of the metallic lines. The mean widening of calcium lines increased slightly during the minimum period. Sodium lines were much affected in the maximum epoch, especially in the large spots. Several lines given by Ångström as "telluric" have been seen widened. The C line has often appeared less dark over sun-spots, but when bright the reversal was generally due to faculæ between the spots. From a total of 2088 individual observations of other lines it is concluded that (1) About the maximum period a great number of faint lines not in Ångström are to be seen in sun-spots. (2) Such lines are not seen exclusively in maximum spots, but reappear in minimum spots when they are large. (3) Some faint lines which have been persistently watched are to be seen greatly widened in every sun-spot, large or small, whether in the disturbed or quiet period. (4) The mean widening of all the five bright chromospheric lines coincident with unknown lines in this region has been low. A Browning automatic spectroscope with a dispersion of twelve prisms of 60° was used for the observations.

TURIN OBSERVATORY.—Some publications of interest have recently been issued from this Observatory. Signor Porro gives the results of observations of the magnitude of the star U (Nova) Orionis throughout a whole period of variation. On November 21, 1889, the star was 8·81 mag.; on April 28, 1890, it was 8·80; and a maximum magnitude = 5·80 was observed on January 21, 1890. Mr. Chandler has given the period of this variable as 371 days, with a maximum on December 7, 1885. Signor Porro finds that the observations made in 1885, in conjunction with those now given, indicate a period of 378·5 days from the epoch December 7.

A large number of determinations of the latitude of Turin has also been made. The mean of 120 observations results in the value $\phi = 45° 4' 7''·942 \pm 0''·029$. The observations do not exhibit the periodic variation observed in the latitude observations made at Berlin, Potsdam, and Prague.

Convenient ephemerides for the sun and moon in 1891 have been calculated for the meridian of Turin by Signor Aschieri. The meteorological observations made in 1889 have been tabulated by Dr. G. B. Rizzo.

THE DUPLICITY OF *a* LYRÆ.—The duplication of the K line in some photographs of the spectrum of Vega taken by Mr. A. Fowler, and from which he inferred that the star was a spectroscopic double of the β Aurigæ type, has not been confirmed by photographs taken by Prof. Pickering, Prof. Vogel, and MM. Henry. Some other explanation must therefore be found to account for the phenomenon.

GASEOUS ILLUMINANTS.[1]

II.

ORDINARY coal gas of an illuminating power of 14 to 16 candles can be produced at a fairly low rate, but if a higher quality is required considerable additional expense has to be incurred in order to enrich it. Up to now, the material almost universally employed for this purpose has been cannel; but as this article is rapidly rising in price, and the best qualities are not easily obtainable, attention is being seriously directed to other means of bringing up the illuminating power of gas. This question of enrichment has been the study of inventors from the earliest days of the gas industry. The methods employed for this purpose may be classified as:—(1) The carburetting of low-power gas by impregnating it with the vapour of volatile hydrocarbons. (2) Enriching the gas by vapours and permanent gases obtained by the decomposition of the tar formed at the same time as the gas. (3) Mixing with the coal gas, oil gas obtained by decomposing crude oils by heat. (4) Mixing with the coal gas, water gas which has been highly carburetted by passing it, with the vapours of various hydrocarbons, through superheaters, in order to give permanency to the hydrocarbon gases.

In the first method, many points have to be taken into consideration, as the hydrocarbons which have from time to time been used for this purpose, vary so greatly in composition; a very volatile naphtha, although it evaporates quickly, and larger quantities of its vapour are taken up by the gas, often giving a less increase of luminosity than a heavier hydrocarbon of which but little is vaporized.

The great trouble which presented itself in the older carburetting systems was that all the commercial samples of naphtha are mixtures of various hydrocarbons, each having its own boiling-point, and that therefore, when used in any of the old forms of carburetters, they gave up their more volatile constituents very freely at the beginning of the experiment, while the amount rapidly diminished as the boiling-point of the residue became higher; so that when 2113 cubic feet of poor coal gas were passed through a naphtha having a specific gravity of 0·869 and a boiling-point of 103° C., the temperature during the experiment being 22° C., the first 80 cubic feet of gas took up 23·2 grains of the naphtha, while the last 450 cubic feet only took up 7·3 grains. Another difficulty found was the increase of evaporation with the rise in the temperature of the gas; as with an ordinary form of carburetter, exposed to atmospheric changes, the enrichment of the gas, which reached 54·4 per cent. in summer with an average temperature of 22° C., fell in winter to only 22 per cent. with an average temperature of 3° C. Of course, in these carburetters a good deal depended upon the form of apparatus; and it was found, on trying different shapes with the same naphtha, that when the gas merely flowed through a box containing a layer of it, only about 3·2 grains were taken up; while with a carburetter in which the naphtha was sucked up by cotton fibre, so as to expose a large surface to the gas, as much as 22 to 23 grains were absorbed. One of the most important points noticed during these experiments was, that it was only a poor gas which could be enriched in this manner, and that if a rich cannel gas was passed through the naphtha, it became robbed of some of its illuminating power.

It must be clearly borne in mind, in approaching this subject, that the evaporation of a hydrocarbon into a permanent gas—*i.e.*, a gas which does not liquefy within the ordinary range of temperature—is a question neither of specific gravity nor of boiling-point, although the latter has more to do with it than the former. It is purely a question of vapour tension. Most liquids, when left to themselves in contact with the atmosphere gradually pass into the state of vapour, and disappear; and those which evaporate most quickly are said to be most volatile. If ether, for example, is dropped upon an exposed surface, it at once disappears, and causes, by its evaporation, considerable cold; and the lightest forms of naphthas do the very same thing. But although this evaporation takes place with rapidity with liquids of low boiling-point, it must not be forgotten that even many solids have the same property—naphthalene, camphor, and iodine being cases in point. It must also be remembered that evaporation occurs over a very wide range of temperature; but that for each substance there is a limit below which evaporation does not seem to take place. So that, when considering the suitability of a liquid for carburetting in this way, it is far more important to determine its vapour tension than its specific gravity or its boiling-point.

So far all systems for carburetting gas with liquid hydrocarbons at the burners have proved failures, but in the albocarbon light the vapour of naphthalene is caused to mingle with the gas just before combustion, the volatilization being effected by a spur of metal heated by the flame itself, which conducts the heat back into a chamber containing solid naphthalene, through which the gas passes, and this process has proved very successful.

Any system to be generally adopted must be applied to the gas in bulk before distribution. In doing this, there are two factors to be considered: the vapour added must be in such proportion to the gases which have to carry them that no fear need exist of their being deposited by any sudden cooling of the gas;

[1] Continued from p. 235.

and care must be taken that the vapour added is not in sufficient quantity to throw out of suspension the volatile hydrocarbons in the gas. The carrying power of a gas depends upon its constituents; for in the same way that liquids vary in their power of dissolving and carrying—*i.e.*, keeping in solution—solids, so do gases vary in their power of bearing away the more volatile hydrocarbons. If the carrying power of air is taken as unity, then the power of ordinary coal gas is about 1·5, while hydrogen would be nearly 3·5; and it is manifest that attention must be paid to the ratio of the constituents present, if gases of varying composition are to be carburetted to the same degree.

During the past few months the idea of the possibility of carburetting coal gas in bulk has again been revived by the construction of an extremely ingenious apparatus, the outcome of the combined engineering skill and practical experience of Messrs. Maxim and Clark, which obviates, to a very great extent, the difficulties which arose with the older forms of carburetter. It has been shown that, when carburetting a gas with a gasoline or light naphtha spirit, the more volatile portions enrich the gas to an undue extent at first, and that, as the process continues, the amount taken up becomes gradually less. This would not so much matter in carburetting the gas in bulk before it went into the holder, as it would become to a great extent mixed by diffusion, and a gas of fairly even illuminating power would result; but the Maxim-Clark apparatus is intended not only to do this, but also to carburet the gas used in large establishments and works.

This apparatus is of such a form that in small installations the whole of the gas to be used can be passed through, and each portion supplied with its own share of hydrocarbon, whilst when carburetting gas in bulk a certain portion can be withdrawn from the main, carburetted and again return it to the main, where, mingling with the steady flow of gas, the whole becomes of uniform composition.

In the earliest days of the gas industry, attempts were made to utilize tar for the production and enrichment of gas; and the patent literature of the century contains many hundred such schemes, most of them being still-born, while a few spent a short and sickly existence, but none achieved success. The reason of this is not difficult to understand. In order to make gas from tar, two methods may be adopted: either to condense the tar in the ordinary way, and afterwards use the whole or portions of it for cracking into a permanent gas; or to crack the tar vapours before condensation by passing the gas and vapours through superheaters. If the first method is adopted, the trouble which at once presents itself, and in a few hours brings the apparatus to grief, is that tar contains 60 per cent. of pitch, which rapidly chokes and clogs up all the pipes; while, if an attempt is made to use a temperature at which the pitch itself is decomposed, it is found that a non-luminous or very poorly luminous gas is the result, and that a heavy deposit of carbon remains in the superheater and retort, and even at high temperatures easily condensable vapours escape, to afterwards create trouble in the pipes.

The most successful attempt to utilize certain portions of the liquid products of the distillation of coal is undoubtedly the Dinsmore process, in which the coal gas and the vapours which, if allowed to cool, would form tar, are made to pass through a heated chamber, and a certain proportion of otherwise condensable hydrocarbons are thus converted into permanent gases. Using a poor class of coal, it is claimed that 9800 cubic feet of 20 to 21 candle gas can be made by this process; while by the ordinary system 9000 cubic feet of 15-candle gas would have been produced.

In distilling the coal in the ordinary way, the yield of tar is 11 gallons per ton; but by the Dinsmore process only 7 gallons. On examining the analysis of the ordinary and Dinsmore tar, it is at once evident that the 4 gallons which have disappeared are the chief portions of the light oils and creosote oils; and these are the factors which have given the increase of illuminating power to the gas.

In enriching a poor coal gas by injecting paraffin oil into the retort during distillation, it must be borne in mind that, as the coal is undergoing distillation, in the earlier stages a rich gas is given off, while towards the end of the operation the gas is very poor in illuminants and rich in hydrogen; the methane disappearing with the other hydrocarbons, and the increase in hydrogen being very marked. Mr. Lewis T. Wright employed a coal requiring six hours for its distillation, and took samples of the gas at different periods of the time. On analysis, these yielded the following results:—

Time after commencement of distillation.	10 min.	1h. 30m.	3h. 25m.	5h. 35m.
Sulphuretted hydrogen...	1·30	1·42	0·49	0·11
Carbon dioxide	2·21	2·09	1·49	1·50
Hydrogen	20·10	38·33	52·68	67·12
Carbon monoxide	6·19	5·68	6·21	6·12
Marsh gas	57·38	44·03	33·54	22·58
Illuminants	10·62	5·98	3·04	1·79
Nitrogen...	2·20	2·47	2·55	0·78

This may be regarded as a fair example of the changes which take place in the quality of the gas during the distillation of the coal. In carburetting such a gas by injecting paraffin into the retort, it would be a great waste to do so for the first two hours, as a rich gas is being given off which has not the power of carrying a very much larger quantity of hydrocarbons—being practically saturated with them. Consequently, to make it take along with it, in a condition not easily deposited, any further quantity, the paraffin would have to be broken down to a great extent; and the temperature necessary to do this would seriously affect the quality of the gas being given off by the coal. When, however, the distillation had gone on for three hours, the rich portions of the coal gas would all have distilled off, and the temperature of the retort would have reached its highest point; and this would be the time to feed in the oil, as its cracking being an exothermic action, the temperature in the retort would be increased, and the gas rich in hydrogen which was being evolved would carry with it the oil gas, and prevent any re-deposition.

When carbon is acted upon at high temperatures by steam, the first action that takes place is the decomposition of the water vapour; the hydrogen being liberated, while the oxygen unites with the carbon to form carbon dioxide, thus—

$$\underset{\text{Carbon.}}{C} + \underset{\text{Water.}}{2(H_2O)} = \underset{\text{Carbon dioxide.}}{CO_2} + \underset{\text{Hydrogen.}}{2H_2}$$

The carbon dioxide so produced interacts with more red-hot carbon, forming the lower oxide, carbon monoxide, thus—

$$CO_2 + C = 2CO.$$

So that the completed reaction may be looked upon as yielding a mixture of equal volumes of hydrogen and carbon monoxide—both of them inflammable, but with non-luminous flames. This decomposition, however, is rarely completed, and a certain proportion of carbon dioxide is invariably to be found in the water gas, which, in practice, generally consists of a mixture of about the following composition:—

Hydrogen	48·31
Carbon monoxide	35·93
Carbon dioxide	4·25
Nitrogen	8·75
Methane	1·05
Sulphuretted hydrogen	1·20
Oxygen	0·51
	100·00

The above is an analysis of water gas made from gas coke in a Van Steenbergh apparatus. The ratio of carbon monoxide and carbon dioxide present depends entirely upon the temperature of the generator and the kind of carbonaceous matter employed. With a hard dense anthracite coal, for instance, it is quite possible to attain a temperature at which there is practically no carbon dioxide produced; while with an ordinary form of generator, and a loose fuel like coke, a large proportion is generally to be found. The sulphuretted hydrogen in the analysis quoted is, of course, due to the high amount of sulphur to be found in the gas coke, and is practically absent from water gas made with anthracite. The nitrogen is due to the method of manufacture; the coke being, in the first instance, raised to incandescence by an air-blast, which leaves the generator and pipes full of a mixture of nitrogen and carbon monoxide (producer gas), which is carried over by the first portions of water gas into the holder. The gas so made has no photometric value—its constituents being perfectly non-luminous; and attempts to use it as an illuminant have all taken the form of incandescent burners, in which thin "mantles" or "combs" of highly refractory metallic oxides are heated up to incandescence. In the case of carburetted water gas, the gas is only used as a carrier of illuminating hydrocarbon gases made by decomposing various grades of hydrocarbon oils into permanent gases by heat.

Water gas generators can be divided into two classes:—(1) Continuous processes, in which the heat necessary to bring about the interaction of the carbon and the steam is obtained by performing the operation in retorts externally heated in a furnace. (2) Intermittent processes, in which the carbon is first heated to incandescence by an air-blast, and the air-blast being cut off, superheated steam is blown in until the temperature is reduced to a point at which the carbon begins to fail in its action, when the air is again admitted to bring the fuel up to the required temperature; the process consisting of the alternate formation of producer gas with rise of temperature, and of water gas with lowering of temperature.

Of the first class of generator, none, so far, have as yet been practically successful in England.

Of the intermittent processes, the one most in use in America is the Lowe, in which the coke or anthracite is heated to incandescence by an air-blast in a generator lined with fire-brick; the heated products of combustion, as they leave the generator and enter the superheaters, being supplied with more air, which causes the combustion of the carbon monoxide present in the producer gas, and heats up the fire-brick baffles with which the superheaters are filled. When the necessary temperature of fuel and superheater has been reached, the air-blasts are cut off, and steam is blown through the generator, forming water gas, which meets the enriching oil at the top of the first superheater, called the "carburetter," and carries the vapours with it through the main superheater, where the firing of the hydrocarbons takes place. The chief advantage of this apparatus is that the enormous superheating space enables a lower temperature to be used for the fixing, which does away to a certain extent with the too great breaking down of the hydrocarbon, and consequent deposition of carbon.

The Springer apparatus differs from the Lowe only in construction. In the former the superheater is directly above the generator; and there is only one superheating chamber instead of two. The air-blast is admitted at the bottom, and the producer gases heat the superheater in the usual way; and when the required temperature is reached, the steam is blown in at the top of the generator, and is made to pass down through the incandescent fuel. The water gas is led from the bottom of the apparatus to the top, where it enters at the summit of the superheater, meets the oil, and passes down with it through the chamber, the finished gas escaping at the middle of the apparatus. This idea of making the air-blast pass up through the fuel, while in the subsequent operation the steam passes down through it, is also to be found in the Loomis plant, and is a distinct advantage—the fuel being at its hottest where the blast has entered, and, in order to keep down the percentage of carbon dioxide, it is important that the fuel through which the water gas last passes should be as hot as possible, to insure its reduction to carbon monoxide.

The Flannery apparatus is also only a slight modification of the Lowe plant, the chief difference being that, as the water gas leaves the generator, the oil is fed into it, and with the gas passes through a D-shaped retort tube, arranged round three sides of the top of the generator. In this tube the oil is volatilized, and passes with the gas to the bottom of the superheater, in which the vapours are converted into permanent gases.

The Van Steenbergh plant stands apart from all other forms of carburetted water gas plant, in that the upper layer of the fuel itself forms the superheater, and that no second part of any kind is needed for the fixation of the hydrocarbons. This arrangement reduces the apparatus to the simplest form, and leaves no part of it which can choke or get out of order—an advantage which will not be underrated by anyone who has had experience of these plants. While, however, an enormous advantage is gained, there is also the drawback that the apparatus is not at all fitted for use with crude oils of heavy specific gravity, such as can be dealt with in the big external superheaters of the Lowe class of water gas plant, but requires to have the lighter oils used in it for carburetting purposes. This, which appears at first sight to be a disadvantage, is not altogether one, as, in the first place, the lighter grade of oils, if judged by the amount of carburetting property they possess, are cheaper per candle-power added to the gas than the crude oils, while their use entirely does away with the formation of pitch and carbon in the pipes and purifying apparatus—a factor of the greatest importance to the gas manufacturers. The fact that light oils give a higher carburation per gallon than heavy crude oils is due to the fact that the crude oils have to be heated to a higher temperature to convert them into permanent gases; and this causes an over-cracking of the most valuabls illuminating constituents. This trouble cannot be avoided, as, if a lower temperature is employed, the result is the formation of non-permanent vapours, which, by their condensation in the pipes, give rise to endless trouble. The simplicity of the apparatus is a factor which is a considerable saving of time and expense, as it reduces to a minimum the risk of stoppages for repairs, while the initial cost of the apparatus is necessarily low, and the expense of keeping it in order practically *nil*.

In such an apparatus 1000 cubic feet of carburetted water gas, having an illuminating value of 22 candles, can be made with the consumption of about 30 pounds of coke or anthracite and 2·5 gallons of light naphtha.

The great objection to the use of carburetted water gas is undoubtedly the poisonous nature of the carbon monoxide, which acts by diffusing itself through the air-cells of the lungs, and forming with the colouring of the blood corpuscles a definite compound, which prevents them carrying off their normal function of taking up oxygen and distributing it throughout the body, and at once stops life. All researches on this subject point to the fact that something less than 1 per cent. only of carbon monoxide in air renders it fatal to animal life; and this at first sight seems to be an insuperable objection to the use of water gas. It has, indeed, influenced the authorities in several towns—notably Paris—to forbid the introduction of water gas for domestic consumption. It would be well, however, to carefully examine the subject, and see, by the aid of actual figures, what the risk amounts to, compared with the risks of ordinary coal gas. Many experiments have been made with the view of determining the percentage of carbon monoxide in air which is fatal to human or rather to animal life, the most trustworthy as well as the latest results being those obtained by Dr. Stevenson, of Guy's Hospital, after an investigation instituted in consequence of two deaths which took place at the Leeds Forge, from inhaling uncarburetted water gas containing 40 per cent. of carbon monoxide. Dr. Stevenson found that 1 per cent. visibly affected a mouse in 1½ minutes, and killed it in an hour and three-quarters, while 0·1 per cent. was highly injurious. Taking, for the sake of argument, the last figure as being a fatal quantity, so as to be well within the mark, it is found that in ordinary carburetted water gas, as supplied by the superheater processes, such as the Lowe, Springer, and others, the usual amount of carbon monoxide is 26 per cent.; but in the Van Steenbergh gas, for certain chemical reasons to be discussed later on, it is generally about 18 per cent., and rarely rises to 20 per cent. An ordinary bedroom is 12 feet by 15 feet and 10 feet high; and therefore it will contain 1800 cubic feet of air. Such a room would be lighted by a single ordinary batswing burner, consuming not more than 4 cubic feet of gas per hour. And if this were left full on, in one hour the 1800 cubic feet of air would be mixed with four-fifths of a cubic foot of carbon monoxide (the carburetted water gas being supposed to contain 20 per cent.) or 0·04 per cent. In such a room, however, if the doors and windows were absolutely air-tight, and there were no fire-place, diffusion through the walls would change the entire air once in an hour. Therefore the percentage would not rise above 0·04; while in any ordinary room, imperfect workmanship and an open chimney would change it four times in the hour, and reduce the percentage to 0·01—a quantity which the most inveterate enemy of water gas could not claim would do more than produce a bad headache. The point under consideration, however, was the use of carburetted water gas as an enricher of coal gas, and not as an illuminant to be consumed *per se*; and it might be calculated that it would be probably used to enrich a 16-candle coal gas up to 17·5-candle power. To do this, 25 per cent. of 12-candle power carburetted water gas would have to be mixed with it. Taking the quantity of carbon monoxide in London gas at 5 per cent. (a very fair average figure), and 18 per cent. as the amount present in the Van Steenbergh gas, we have 8·25 per cent. of carbon monoxide in the gas as sent out—a percentage hardly exceeding that which is found in the rich cannel gas supplied to such places as Glasgow, where it is not found that an unusual number of deaths occur from carbon monoxide poisoning. Moreover, carburetted water gas has quite as strong a smell as coal gas, and can be quite as easily detected by the nose.

The cost of most of these methods of enriching coal gas can be calculated, and give the following figures as the cost of enriching a 16-candle gas up to 17·5-candle power per 1000 cubic feet:—

By cannel coal	4*d.*
By the Maxim-Clark process	$2\frac{6}{10}$*d.*
By the Lowe or Springer water gas	$1\frac{1}{2}$*d.*
By the Van Steenbergh water gas	$\frac{3}{4}$*d.*

In adopting any new method, the mind of the gas manager must, to a great extent, be influenced by the circumstances of the times; and the enormous importance of the labour question is a main factor at the present moment. With masters and men living in a strained condition, which may at any moment break into open warfare, the adoption of such water gas processes would relieve the manager of a burden which is growing almost too heavy to be borne. Combining, as such processes do, the maximum rate of production with the minimum amount of labour, they practically solve the labour question.

The cost of paraffin oil of lighter grades, and the fear that the supply might be hampered by the formation of a huge monopoly, has been a great drawback, but we have materials which can be equally well used in this country of which an almost unlimited supply can be obtained.

At three or four of the Scotch iron-works, the Furnace Gases Company are paying a yearly rental for the right of collecting the smoke and gases from the blast-furnaces. These are passed through several miles of wrought-iron tubing, gradually diminishing in size from 6 feet to about 18 inches; and as the gases cool there is deposited a considerable yield of oil. At Messrs. Dixon's, in Glasgow, which is the smallest of these installations, they pump and collect about 60,000,000 feet of furnace gas per day, and recover, on an average, 25,000 gallons of furnace oils per week; using the residual gases, consisting chiefly of carbon monoxide, as fuel for distilling and other purposes, while a considerable yield of sulphate of ammonia is also obtained. In the same way a small percentage of the coke-ovens are fitted with condensing gear, and produce a considerable yield of oil, for which, however, there is but a very limited market; the chief use being for the Lucigen light, and other lamps of the same description, and also for pickling timber for railway sleepers, &c. The result is that four years ago the oil could be obtained in any quantity at $\frac{1}{2}$*d.* per gallon; though it has since been as high as $2\frac{1}{2}$*d.* per gallon. It is now about 2*d.* per gallon, and shows a falling tendency. Make a market for this product, and the supply will be practically unlimited, as every blast-furnace and coke-oven in the kingdom will put up plant for the recovery of the oil. As, with the limited plant now at work, it would be perfectly easy to obtain 4,000,000 or 5,000,000 gallons per annum, an extension of the recovery process would mean a supply sufficiently large to meet all demands.

Many gas managers have from time to time tried if they could not use some of their creosote oil for producing gas; but, on heating it in retorts, &c., they have found that the result has generally been a copious deposit of carbon, and a gas which has possessed little or no illuminating value. Now the furnace and coke-oven oils are in composition somewhat akin to the creosote oil; so that, at first sight, it does not seem a hopeful field for search after a good carburetter. But the furnace oils have several points in which they differ from the coal-tar products. In the first place, they contain a certain percentage of paraffin oil; and, in the next, do not contain much naphthalene, in which the coal-tar oil is especially rich, and which would be a distinct drawback to their use. The furnace oil, as condensed, contains about 30 to 50 per cent. of water; and, in any case, this has to be removed by distilling. Mr. Staveley has patented a process by which the distillation is continued after the water has gone off, and by condensing in a fractionating column of special construction, he is able to remove all the paraffin oil, a considerable quantity of cresol, a small quantity of phenol, and about 10 per cent. of pyridine bases, leaving the remainder of the oil in a better condition, and more valuable for pickling timber, its chief use.

If the mixed oil so obtained, which we may call "phenoloid oil," is cracked by itself, no very striking result is obtained; the 40 per cent. of paraffin present cracking in the usual way, and yielding a certain amount of illuminants. But if the oil is cracked in the presence of carbon, and is made to pass over and through a body of carbon heated to a dull red heat, it is converted largely into benzene. As this is the most valuable of the illuminants in coal gas, and also the one to which it owes the largest proportion of its light-giving power, it is manifestly the right one to use in order to enrich it. On cracking the phenoloid oil, the paraffin yields ethane, propane, and marsh gas, &c., in the usual way; while the phenol interacts with the carbon to form benzene:—

$$\underset{\text{Phenol.}}{C_6H_5HO} + C = \underset{\text{Benzene.}}{C_6H_6} + CO.$$

And in the same way the cresol first breaks down to toluene in the presence of the carbon; and this in turn is broken down by the heat to benzene. A great advantage this oil has is that the flashing-point is 110° C., and so is well above the limit; this doing away with the dangers and troubles inseparable from the storage of light naphthas in bulk.

In using this oil as an enricher, it must be cracked in the presence of carbon; and it is of the greatest importance that the temperature should not be too high, as the benzene is easily broken down to simpler hydrocarbons of far lower illuminating value.

(*To be continued.*)

SCIENTIFIC SERIALS.

American Journal of Science, December 1890.—Long Island Sound in the Quaternary era, with observations on the submarine Hudson River channel, by James D. Dana. The discussion of a chart containing some new soundings recently made under the direction of the U.S. Coast and Geodetic Survey leads Prof. Dana to conclude that during the Glacial period "Long Island Sound, instead of being, as it is now, an arm of the ocean twenty miles wide, was for the greater part of its length a narrow channel serving as a common trunk for the many Connecticut and some small Long Island streams, and that the southern Sound river reached the ocean through Peconic Bay. Under these circumstances the supply of fresh water for the Sound river would have been so great that salt water would have barely passed the entrance of the Sound." He attributes the origin of the channel over the submerged Atlantic border to the flow of the Hudson River during a time of emergence.—The preservation and accumulation of cross-infertility, by John T. Gulick. The author discusses some of the conclusions arrived at by Mr. Wallace in his work on "Darwinism."—The deformation of Iroquois Beach and birth of Lake Ontario, by J. W. Spencer. The author believes that the great Iroquois Beach was constructed approximately at sea-level and that its upheaval was the means that gave birth to Lake Ontario. This episode commenced almost synchronously with the creation of the Niagara Falls.—Experiments upon the constitution of the natural silicates, by F. W. Clarke and E. A. Schneider.—Eudialyte and eucolite, from Magnet Cove, Arkansas, by J. Francis Williams.—Prediction of cold waves from Signal Service weather maps, by T. Russell. In addition to the regular fall of temperature that takes place from day to night, irregular falls occur from time to time. When the fall in the latter case exceeds 20°, and covers an area greater than 50,000 square miles, and the temperature in any part of the area falls as low as 36°, it is called a cold wave. The author has investigated the shapes and relative positions of the various high and low areas of pressure preceding cold waves, and proposes a method for the prediction of them.—On a peculiar method of sand transportation by rivers, by James C. Graham. Numerous blotches of sand, some about six inches square, have been observed floating on the surface of the Connecticut River. This indicates that, by surface tension, it is possible for coarse sand to be floated away on a current having less velocity than would otherwise be required, and affords a possible explanation of the coarser particles of sand usually found in otherwise very fine deposits.—Note on the Cretaceous rocks of Northern California, by J. S. Diller.—Magnetic and gravity observations on the west coast of Africa and at some islands in the North and South Atlantic, by E. D.

Preston.—On the Fowlerite variety of rhodonite from Franklin and Stirling, N.J., by L. V. Pirsson.—Some observations on the beryllium minerals from Mount Antero, Colorado, by S. L. Penfield.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, December 11, 1890.—"On Stokes's Current Function." By R. A. Sampson, Fellow of St. John's College, Cambridge. Communicated by Prof. Greenhill, F.R.S.

In a liquid any irrotational motion which is symmetrical about an axis may be regarded as due to the juxtaposition at the origin and upon the axis of symmetry of sinks and sources.

Let us consider the system formed by a line source and a line sink, of equal strengths, extending along the axis from an arbitrary origin to infinity in opposite directions. Such a system I shall call an *extended doublet*, of strength m, where m is the strength per unit length of that part which lies on the positive side of the origin.

By the superposition of two extended doublets, of equal but opposite strengths, we can produce a sink or a source upon the axis. Hence, in a liquid, any irrotational motion which is symmetrical with respect to an axis may be produced by superposition of extended doublets, whose origins depart but little from an arbitrary point on the axis of symmetry.

Now, for an extended doublet of strength m, we find Stokes's current function ψ, for any point distant r from the origin $= -2mr$. Whence, if $r \sin\theta = \varpi$, $r\cos\theta = z - \zeta$, $\mu = \cos\theta$

$$\frac{d^2\psi}{d\varpi^2} + \frac{d^2\psi}{dz^2} - \frac{1}{\varpi}\frac{d\psi}{d\varpi} = 0 = \frac{d^2\psi}{dr^2} + \frac{1-\mu^2}{r^2}\frac{d^2\psi}{d\mu^2}.$$

Thus it will be seen that the direct distance of any point from a point on the axis of symmetry plays the same part in the theory of Stokes's current function that is played by its reciprocal in the theory of the potential function belonging to symmetrical distributions of matter.

And if r_0, 0, r, θ, be the co-ordinates of a point upon the axis, and of any other point, the distance between these points, $\sqrt{(r_0^2 - 2r_0 r\cos\theta + r^2)}$, may be developed in a convergent series, say

$$\sum_{n=0}^{n=\infty} - \frac{r^n}{r_0^{n-1}} \mathrm{I}_n(\cos\theta),$$

or

$$\sum_{n=0}^{n=\infty} - \frac{r_0^n}{r^{n-1}} \mathrm{I}_n(\cos\theta),$$

according as r_0 is greater or less than r, $\mathrm{I}_n(\cos\theta)$ being a certain function of θ, satisfying

$$(1-\mu^2)\frac{d^2\mathrm{I}_n(\mu)}{d\mu^2} + n(n-1)\mathrm{I}_n(\mu) = 0.$$

It is evident from the analogue of zonal harmonics that it is proper to discuss the function $\mathrm{I}_n(\cos\theta)$, and other solutions of this equation, before considering the applications of Stokes's current function to the motion of liquids. As might be expected, the theory closely resembles that of spherical harmonics.

The applications to hydrodynamics which I here give are chiefly in connection with the motion of viscous liquids. In *Crelle-Borchardt*, vol. lxxxi., 1876, Oberbeck has given the velocities produced in an infinite viscous liquid by the steady motion of an ellipsoid through it, in the direction of one of its axes, and from these Mr. Herman (*Quart. Journ. Math.*, 1889, No. 92) has found the equation of a family of surfaces containing the stream lines relative to the ellipsoid. I obtain Stokes's current function by a direct process for the flux of a viscous liquid past a spheroid, and it is shown that the result differs only by a constant multiple from the particular case of Mr. Herman's integral.

Some minor applications are also given—namely, the solutions are obtained for flux past an approximate sphere, and past an approximate spheroid. The solution is also obtained for flux through a hyperboloid of one sheet, where it appears that the stream surfaces are hyperboloids of the confocal system. A particular case is that of flux through a circular hole in a wall, and this is interesting because we see that, by supposing internal friction to take place in the liquid, we find an expression which gives zero velocity at the sharp edge, and thus avoids the difficulty which is always present in the solution of such problems on the supposition that the liquid is perfect.

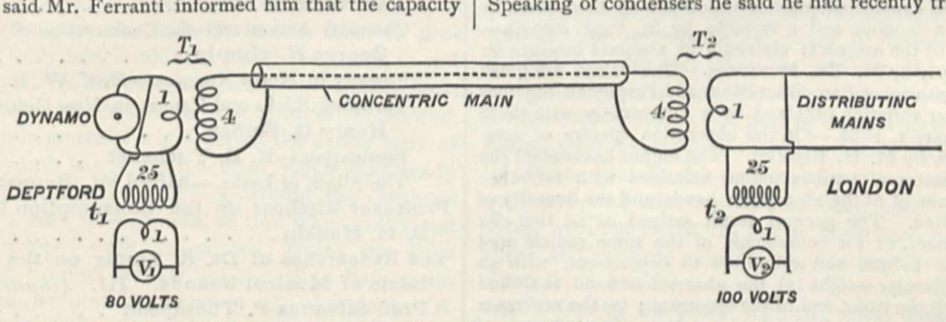
The paper concludes with an attempt to discuss the flux past a spheroid, or through a hyperboloid at whose boundary there may be slipping. The current function is not obtained, all that appears being that it probably differs from the parallel case of the sphere in being far more complicated than when there is no slipping. From this we except the case of the flux through a circular hole in a plane wall, when the solution for no slipping satisfies the new conditions.

Chemical Society, November 6, 1890.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—The magnetic rotation of saline solutions, by Dr. W. H. Perkin, F.R.S. The remarkable results given by solutions of the halhydrides and their compounds with ammonia and organic bases when examined as to their magnetic rotatory power (Chem. Soc. Trans., 1889, 740) made it important to study the solutions of metallic salts in a similar manner. The substances which have been examined up to the present are chiefly chlorides, bromides, iodides, nitrates, a nitrite, sulphates, and phosphates, also hydroxides of alkali metals. For haloid metallic salts in aqueous solution, the rotations were found to be practically 2·2 times greater than the calculated values for the dry substances, and greater therefore than those of the analogous ammonium compounds. A similar remarkable increase of rotation was observed with the hydroxides of the alkali metals, but with sulphates and phosphates numbers agreeing much more closely with the calculated values were obtained. In the discussion which followed the reading of the paper, Dr. Gladstone, F.R.S., said that similar excessive values were obtained on determining the refractive powers of solutions of metallic chlorides, &c., although the differences between the calculated and observed values were much smaller than in the case of Dr. Perkin's measurements. It was all-important to determine the difference in behaviour to light of a substance in its solid state and when in solution, but this was difficult as few solids were uniaxial; as an example of the difference he mentioned that in the case of sodium chloride the solid has a refraction of 14·4, while that of the dissolved substance is 15·3.—Note on normal and isopropylparatoluidine, by Mr. E. Hori and Dr. H. F. Morley.—The action of light on ether in the presence of oxygen and water, by Dr. A. Richardson. In a recent paper by Dunstan and Dymond (Chem. Soc. Trans., 1890, 574) it is stated that hydrogen peroxide is not formed when carefully purified ether is exposed at a low temperature in contact with air and water to the electric light or diffused daylight. Employing ether which had been purified by some of the methods of Dunstan and Dymond, the author found that hydrogen peroxide is formed in the liquid in every case after exposure to sunlight in contact with moist air or oxygen, but not in the dark at the ordinary temperature.—Action of ammonia and methylamine on the oxylepidens, by Dr. F. Klingemann and Mr. W. F. Laycock.—Condensation of acetone-phenanthraquinone, by Mr. G. H. Wadsworth.—Action of phosphorus pentachloride on mucic acid, by Dr. S. Ruhemann and Mr. S. F. Dufton.—Halogens and the asymmetrical carbon atom, by Mr. F. H. Easterfield. The author has endeavoured to prepare optically active haloid derivatives similar in constitution to Le Bel's optically active secondary amyl iodide, which at present stands alone as the only active compound in which a halogen is united to the asymmetric carbon atom. The results obtained with optically active mandelic acid were negative.

November 20.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—A new method of determining the specific volumes of liquids and of their saturated vapours, by Prof. S. Young. When a tube closed at both ends and partly filled with a liquid is raised in temperature, the liquid expands, but the apparent expansion is less than the real, for a certain amount of the substance separates and occupies the space above the liquid in the form of saturated vapour. If the density of the vapour were known, it would be possible to apply the necessary correction; but at high temperatures and pressures this is not the case. If, on the other hand, the upper part of the tube (enclosing the vapour and a portion of the liquid) be heated to a high temperature, the lower part being kept at a constant low temperature, and if subsequently a greater length of the tube be heated to the high temperature, there will again be expansion, but in this case the observed expansion will be greater than the real, for in consequence of the diminution in volume of the saturated vapour, a portion of it must have condensed. In both cases there are the same two unknown values, the true volume of the liquid and the specific volume of the vapour, and from the two equations involving the experimental data it is, therefore, possible to calculate both values. The experimental method based on these principles possesses the following advantages: it is applicable to substances such as nitrogen peroxide or bromine which attack mercury; it is available for a very wide range of temperature and pressure, even to the critical point of many substances; the data obtained serve to determine not only the specific volume of the liquid, but also that of its saturated vapour.—The molecular condition of metals when alloyed with each other, by Messrs. C. T. Heycock and F. H. Neville. The authors in their earlier experiments (Chem. Soc. Journ., 1890, 376) showed that one atomic proportion of a metal when dissolved in tin produces a fall in the freezing-point that on the theory of osmotic pressure should be produced by one molecular proportion, and therefore concluded that when metals are dissolved in tin their molecules are monatomic. Further experiments with other metals as solvents have led to the following results:—Of fourteen metals dissolved in bismuth, seven (viz. lead, thallium, mercury, tin, palladium, platinum, and cadmium) have monatomic molecules; of fifteen metals dissolved in cadmium, seven (viz. antimony, platinum, bismuth, tin, sodium, lead, and thallium) have monatomic molecules; and of fourteen metals dissolved in lead, five (viz. gold, palladium, silver, platinum, and copper) have monatomic, and three (viz. mercury, bismuth, and cadmium) have diatomic molecules.—The estimation of cane sugar, by Messrs. C. O'Sullivan, F.R.S., and F. W. Tompson.—The spectra of blue and yellow chlorophyll, with some observations on leaf-green, by Prof. W. N. Hartley, F.R.S. The author draws the following conclusions from the results of his investigation of the different colouring-matters described under the name chlorophyll:—(1) Living tissues which are fresh and young, and which therefore contain the leaf-green unaltered, exhibit no trace of a band close to D, such as is usually attributed to chlorophyll, and there is no indication of one in the green. (2) Yellow chlorophyll has a distinct absorption-band in the red differing from that of blue chlorophyll. It has likewise a distinct fluorescence. (3) When light is concentrated on living tissues the absorption spectrum of the green colouring-matter is soon altered. (4) Blue chlorophyll may be extracted from minced leaves by cold absolute alcohol, and may be precipitated by addition of baryta. Yellow chlorophyll is not so precipitated, or not precipitated so readily. A warm solution of boracic acid in glycerine, mixed with a little alcohol, liberates the unchanged blue chlorophyll from the dried barium compound. (5) Blue chlorophyll exhibits two absorption-bands in the red, close together; in the less refrangible region of rays one overlies B and the other overlies C. There is a feebler band near D. (6) Concentrated solutions of yellow chlorophyll in benzene are brownish in colour, and exhibit a magnificent red fluorescence. (7) When blue and yellow chlorophyll are separately treated with formic acid and ether, there are produced two new substances showing absorption-bands in the green. It is believed that when these bands have been observed, either in preparations of chlorophyll or in living tissues, the chlorophyll has been altered by oxidation of formic aldehyde in the plant. This oxidation could be caused in living tissues by an excessive degree of illumination, which causes the destruction of the tissues, and otherwise by exposure of the contents of the plant-cells to air or oxygen. An excessive illumination causes an exceedingly great activity in decomposing carbonic acid, and probably oxygen cannot be respired sufficiently rapidly; hence there may be a reverse action, or an oxidation of formic aldehyde to formic acid. (8) The leading characteristics of unaltered leaf-green are those of blue chlorophyll—namely, an intense absorption in the red, stronger even than in the violet or ultra-violet.—Note on dibenzanilide, by Dr. J. B. Cohen.

December 4.—Dr. W. J. Russell, F.R.S., President, in the chair.—The following papers were read:—The action of heat on ethylic β-amidocrotonate, by Dr. J. N. Collie.—The action of heat on nitrosyl chloride, by Messrs. J. J. Sudborough and G. H. Miller. An account is given of a series of determinations of the vapour-density of nitrosyl chloride at various temperatures. At temperatures from 15° to 693°, the values obtained so nearly coincide with the theoretical value 32·67 that it is to be supposed that no dissociation takes place below 700°. At higher temperatures the compound is no longer stable. The results show that in comparison with nitrogen dioxide, which is completely decomposed below 620°, nitrosyl chloride is a highly stable compound.—The volumetric estimation of tellurium, by Dr. B. Brauner.

Physical Society, December 12, 1890.—Prof. W. E. Ayrton, President, in the chair.—Mr. Shelford Bidwell, F.R.S., showed some experiments with selenium cells. The crystalline variety of selenium was, he said, most interesting to physicists, owing to its electrical resistance being greatly diminished by light. This property was shown experimentally with different forms of cells, the construction of which was explained. The form recommended was that in which two copper wires are wound near each other round a slip of mica, and the spaces between the wires filled with selenium. The wires form the terminals of the so-called "cell," which, before being used, is annealed for several hours at a temperature above 200° C. Many such cells were made in 1880, 1881, and their sensitiveness to light remained unimpaired during 1882. In 1885, however, several were found less sensitive, and others totally useless; only one out of thirteen retained its sensibility till September 1890. The loss of sensitiveness Mr. Bidwell believes due to an excessive amount of selenide of copper being formed, for, although some selenide is essential to the satisfactory working of the cell, too much is fatal to its action. The selenide of one defective cell was electrolyzed, red tufts of amorphous selenium appearing on the anodes. A white substance resembling moist calcium chloride was also present; this he believed to be oxide or hydroxide of selenium. Small polarization currents had been obtained from selenium cells. A lecture apparatus illustrating the properties of selenium cells was exhibited. It consisted of a cell connected in series with a relay and a battery. The relay was arranged so that it might either ring a bell, or light an incandescent lamp. When the bell was joined up, it remained silent so long as the selenium cell was illuminated, but on screening the cell, the bell rang. By using various coloured glasses as screens, the effect was shown to be due to the red and yellow rays. A similar experiment with the glow lamp was very striking, for on turning down the gas-lamp illuminating the cell, the electric lamp lighted, and was extinguished on turning up the gas. This demonstrated the possibility of an automatic lamp-lighter, which would light or put out lamps according as they are required or superfluous. Amongst the other practical applications suggested were, announcing the accidental extinction of railway-signal lamps or ships' lights, and the protection of safes and strong rooms. Prof. Minchin said he had lately constructed cells of a different kind from those shown by Mr. Bidwell, and found that they gave an E.M.F. when exposed to light. For his purposes the long annealings, &c., were quite unnecessary, and a complete cell could be made in ten minutes. One of his cells gave an E.M.F. of over 0·25 volt as measured by an electrometer, by the light of a fog. Their promptness of action falls off in a day or two, but if they are kept on open circuit a week has no effect on the final E.M.F. On closed circuit, however, they deteriorate. Prof. S. U. Pickering said both oxides of selenium were deliquescent, and the author's conclusion as to the white substance formed by electrolysis was probably correct. Prof. S. P. Thompson believed Prof. Graham Bell had tried platinum instead of copper, and found that the selenium cracked off in annealing. He also found that it was only necessary to carry on the annealing until the characteristic slate colour appeared. Mr. Bidwell's experiments, he said, showed the possibility of seeing at a distance, and had also suggested to him that the effect of screening might be utilized for driving a completely detached pendulum electrically. Prof. Forbes said that silver sulphide when electrolyzed presented appearances resembling those noticed by Mr. Bidwell in copper selenide. In reply to questions from the President and Prof. Perry, as to whether the low resistance and unsensitiveness of old cells was due to moisture, Mr. Bidwell said drying them had no effect, but baking restored the resistance but not their sensitiveness. Speaking of the effect of annealing cells, he said this reduced their resistance considerably. Prof. Graham Bell, he believed, gave up using platinum because the resistances of such cells were very high.—Mr. James Swinburne read a paper on Alternate Current Condensers. It is, he said, generally assumed that there is no difficulty in making commercial condensers for high-pressure alternating currents. The first difficulty is insulation, for the dielectric must be very thin, else the volume of the condenser is too great. Some dielectrics 0·2 mm. thick can be made to stand up to 8000 volts when in small pieces, but in complete condensers a much greater margin must be allowed. Another difficulty arises from absorption, and whenever this occurs the apparent capacity is greater than the calculated. Supposing the fibres of paper in a paper condenser to be conductors embedded in insulating hydrocarbon, then every time the condenser is charged the fibres have their ends at different potentials, so a current passes to equalize them and energy is lost. This current increases the capacity. One condenser made of paper boiled in ozokerite took an abnormally large current and heated rapidly. At a high temperature it gave off water, and the power wasted and current taken gradually decreased. When a thin plate of mica is put between tin foils, it heats excessively; and the fall of potential over the air films separating the mica and foil is great enough to cause disruptive discharge to the surface of the mica. There appears to be a luminous layer of minute sparks under the foils, and there is a strong smell of ozone. In a dielectric which heats, there may be three kinds of conduction: viz. metallic, when an ordinary conductor is embedded in an insulator; disruptive, as probably occurs in the case of mica; and electrolytic, which might occur in glass. In a transparent dielectric the conduction must be either electrolytic or disruptive, otherwise light vibrations would be damped. The dielectric loss in a cable may be serious. Calculating from the waste in a condenser made of paper soaked in hot ozokerite, the loss in one of the Deptford mains came out 7000 watts. Another effect observed at Deptford is a rise of pressure in the mains. There is as yet no authoritative statement as to exactly what happens, and it is generally assumed that the effect depends on the relation of capacity to self-induction, and is a sort of resonator action. This would need a large self-induction, and a small change of speed would stop the effect. The following explanation is suggested. When a condenser is put on a dynamo, the condenser current leads relatively to the electromotive force, and therefore strengthens the field magnets and increases the pressure. In order to test this, the following experiment was made for the author by Mr. W. F. Bourne. A Gramme alternator was coupled to the low-pressure coil of a transformer, and a hot-wire voltmeter put across the primary circuit. On putting a condenser on the high-pressure circuit, the voltmeter wire fused. The possibility of making an alternator excite itself like a series machine, by putting a condenser on it, was pointed out. Prof. Perry said it would seem possible to obtain energy from an alternator without exciting the magnets independently, the field being altogether due to the armature currents. Mr. Swinburne remarked that this could be done by making the rotating magnets a star-shaped mass of iron. Sir W. Thomson thought Mr. Swinburne's estimate of the loss in the Deptford mains was rather high. He himself had calculated the power spent in charging them, and found it to be about 16 horse-power, and although a considerable fraction might be lost, it would not amount to nine-sixteenths. He was surprised to hear that glass condensers heated, and inquired whether this heating was due to flashes passing between the foil and the glass. Mr. A. P. Trotter said Mr. Ferranti informed him that the capacity of his mains was about $\frac{1}{3}$ microfarad per mile, thus making $2\frac{1}{3}$ microfarads for the seven miles. The heaping up of the potential only took place when transformers were used, and not when the dynamos were connected direct. In the former case the increase of volts was proportional to the length of main used, and 8500 at Deptford gave 10,000 at London. Mr. Blakesley described a simple method of determining the loss of power in a condenser by the use of three electro-dynamometers, one of which has its coils separate. Of these coils, one is put in the condenser circuit, and the other in series with a non-inductive resistance r, shunting the condenser. If a_2 be the reading of a dynamometer in the shunt circuit, and a_3 that of the divided dynamometer, the power lost is given by $r\,(Ca_3 - Ba_2)$ where B and C are the constants of the instruments on which a_2 and a_3 are the respective readings. Prof. S. P. Thompson asked if Mr. Swinburne had found any dielectric which had no absorption. So far as he was aware, pure quartz crystal was the only substance. Prof. Forbes said Dr. Hopkinson had found a glass which showed none. Sir W. Thomson, referring to the same subject, said that many years ago he made some tests on glass bottles, which showed no appreciable absorption. Sulphuric acid was used for the coatings, and he found them to be completely discharged by an instantaneous contact of two balls. The duration of contact would, according to some remarkable mathematical work done by Hertz in 1882, be about 0·0004 second, and even this short time sufficed to discharge them completely. On the other hand, Leyden jars with tin-foil coatings, showed considerable absorption, and this he thought due to want of close contact between the foil and the glass. To test this he suggested that mercury coatings be tried. Mr. Kapp considered the loss of power in condensers due to two causes: first, that due to the charge soaking in; and second, to imperfect elasticity of the dielectric. Speaking of the extraordinary rise of pressure on the Deptford mains, he said he had observed similar effects with other cables. In his experiments the sparking distance of a 14,000-volt transformer was increased from $\frac{3}{16}$ of an inch to 1 inch by connecting the cables to its terminals. No difference was detected between the sparking distances at the two ends of the cable, nor was any rise of pressure observed when the cables were joined direct on the dynamo. In his opinion the rise was due to some kind of resonance, and would be a maximum for some particular frequency. Mr. Mordey mentioned a peculiar phenomenon observed in the manufacture of his alternators. Each coil, he said, was tested to double the pressure of the completed dynamo, but when they were all fitted together their insulation broke down at the same volts. The difficulty had been overcome by making the separate coils to stand much higher pressures. Prof. Rücker called attention to the fact that dielectrics alter in volume under electric stress, and said that if the material was imperfectly elastic some loss would result. The President said that, as some doubt existed as to what Mr. Ferranti had actually observed, he would illustrate the arrangements by a diagram. Speaking of condensers he said he had recently tried lead plates



T_1 and T_2 are large transformers; t_1 and t_2 are small transformers or voltmeters V_1 and V_2. The numbers 1, 4, 1, 25, represent their conversion ratios.

in water to get large capacities, but so far had not been successful. Mr. Swinburne, in replying, said he had not made a perfect condenser yet, for, although he had some which did not heat much, they made a great noise. He did not see how the rise of pressure observed by Mr. Ferranti and Mr. Kapp could be due to resonance. Mr. Kapp's experiment was not conclusive, for the length of spark is not an accurate measure of electromotive force. As regards Mr. Mordey's observation, he thought the action explicable on the theory of the leading condenser current acting on the field magnets. The same explanation is also applicable to the Deptford case, for when the dynamo is direct on, the condenser current is about 10 amperes, and this exerts only a small influence on the strongly magnetized magnets. When transformers are used the field magnets are weak, whilst the condenser current rises to 40 amperes. Mr. Blakesley's method of determining losses was, he said, inapplicable except where the currents were sine functions of the time; and consequently could not be used to determine loss due to hysteresis in iron, or in a transparent dielectric.—Mr. Swinburne's note on electrolysis was postponed till the next meeting.

Linnean Society, December 18, 1890.—Prof. Stewart, President, in the chair.—Prof. T. Johnson exhibited and made remarks on the male and female plants of *Stenogramme interrupta*.—Mr. Clement Reid exhibited specimens of *Helix obvoluta* from new localities in Sussex, and by aid of a specially prepared map traced the present very local distribution of this mollusc in England.—Mr. E. M. Holmes exhibited some examples of galls formed on *Styrax benzoin* by an Aphis (*Ætegopteris styracophila*). He also exhibited and described some new British Algæ, *Mesoglœa lanosa* and *Myriocladia tomentosa*.—A paper was then read by Prof. R. J. Harvey Gibson on the structure and development of the cystocarps in *Catanella opuntia*, and critical remarks were offered by Messrs. D. H. Scott, E. M. Holmes, and others.—Mr. G. F. Scott Elliot then read an interesting paper on the effect of exposure on the relative length and breadth of leaves, upon which a discussion followed.

Mathematical Society, January 8.—Prof. Greenhill, F.R.S., President, in the chair.—Mr. H. Perigal, in a communication on geometrical metamorphoses by partition and transformation, exhibited a great number of interesting dissections, starting from his now classical dissection of Euc. i. 47, which dates from the year 1835.—Major Macmahon, R.A., F.R.S., then gave an account of a theory of perfect partitions and the compositions of multipartite numbers.—Mr. Tucker read a paper, by Prof. G. B. Mathews, on a certain class of plane quartics.

PARIS.

Academy of Sciences, January 5.—M. Duchartre in the chair.—M. d'Abbadie was elected Vice-President for the year 1891.—On the waves caused by explosions, the characteristics of detonations, and the velocity of propagation in solid and liquid bodies, and especially in methyl nitrate, by M. Berthelot. Methyl nitrate, CH_3NO_3, may give by explosion $CO_2 + CO + N_2 + 3H_2O$, or $2CO_2 + N_2 + H_2 + 2H_2O$. In both cases the volume of the gas generated is the same, viz. 1028 litres for 1 kilogramme, the heat of decomposition being 1451 calories. These numbers are very nearly the same as those furnished by nitro-glycerine and gun-cotton. The pressure developed when 1 kilogramme of methyl nitrate is exploded in a vessel of 1 litre capacity, is no less than 11,000 kilogrammes per square centimetre. The author has attempted to measure the velocity of propagation of the waves, but the vessels employed were always broken by the shock. A calculation shows that the resistance offered by the vessels only increases with the thickness up to a certain limiting pressure. The pressure developed above this limit has infinite force, hence nothing can resist it.—On a class of modulary equations, by M. Brioschi.—On some linear differential equations capable of transformation among themselves by a change of a function and a variable, by M. Paul Appell.—On the value of the magnetic elements in absolute measure on January 1, 1891, by M. Th. Moureaux. The values are given for the Observatories of Parc Saint-Maur and Perpignan, together with the secular variation obtained by a comparison with those found on January 1, 1890.—On the absorption spectra of solutions of iodine, by M. H. Rigollot. The author has studied the absorption spectra of various iodine solutions with reference to the displacement of the absorption bands and the quantity of light transmitted. The general result arrived at is, that for similar substances, or for compounds of the same radicle used as solvents for iodine, and submitted to experiment, with an increase of molecular weight (1) the absorption band is shifted slightly towards the violet end of the spectrum; (2) the minimum amount of light received diminishes in value.—The influence of tempering on the electrical resistance of steel, by M. H. Le Chatelier. The experiments show that the measure of electrical resistance may be used to determine the state of carbon in iron, and also to find the proportion transformed in tempered steel. This method will be adopted in further researches on the mechanical properties of steel.—Influence of the *covolume* of gases on the velocity of propagation of explosive phenomena, by M. Vielle. (See M. Berthelot's paper above.)—On the conductivities of isomeric organic acids and their salts, by M. Daniel Berthelot. From the observation at 17° C. of the conductivities of dilute solutions of oxybenzoic, of amidobenzoic, of maleic and fumaric, of itaconic, metaconic, and citraconic, and of racemic, dextro-rotatory tartaric, and inactive tartaric acids in solutions containing the free acids alone and with varying quantities of potash, the author concludes that the rule given by M. Arrhenius for the calculation of the conductivities of isohydric solutions is rigorously true in the case of monobasic acids.—On trithienyl, by M. Adolphe Renard. The analyses of this body indicate that its formula is $C_4H_3S—C_4H_2S—C_4H_3S$. Its vapour density is 8·6 by Meyer's method; theory requires it to be 8·68.—Action of sodium benzylate upon camphor cyanide, by M. J. Minguin.—On a general method of analysis applicable to the spirits and alcohols of commerce, by M. Ed. Mohler.—The method described is asserted to permit of the determination of not only the alcohol, extract, acidity, and furfurol, but, in addition, the ethers, aldehydes, higher alcohols, and nitrogenous bodies.—On the urinary function of acephalian mollusks—viz. the Bojanus organ and the Keber and Grobben glands, by M. Augustin Letellier.—On the development of the chromatophores of octopodian cephalopods, by M. L. Joubin.—On *Atlantonema rigida*, v. Siebold, the parasite of various Coleoptera, by M. R. Moniez.—On the position of the chalk of Touraine, by M. A. de Grossouvre.—Contributions to the geological knowledge of the Alpine chains between Moutiers (Savoy) and Barcelonnette (Lower Alps): formations prior to the Jurassic, by M. W. Kilian.—Soundings of Lake Leman, by M. A. Delebecque. This lake is composed of two parts—the great lake, between Nernier and Villeneuve; and the little lake, between Nernier and Geneva. The great lake has a mean depth of 310 metres. At the junction with the Geneva lake the transverse barrier of an old moraine rises, and the depth is only about 70 metres. The mean depth of the whole lake appears to be about 153 metres.

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