THURSDAY, SEPTEMBER 16, 1909.

PRINCIPLES OF IGNEOUS PETROLOGY.

The Natural History of Igneous Rocks. By A. Harker, F.R.S. Pp. xvi+384. (London: Methuen, 1909.) Price 12*s.* 6*d.* net.

FOR some time the need of a text-book of general petrology in English has been acutely felt, owing to the rapid progress which the science has made in theoretical subjects and the inaccessibility of many of the original memoirs to students and teachers. Most text-books treat the subject from a purely descriptive point of view, and the speculative developments are kept in the background. In fact the literature of descriptive petrology is now so large that an attempt to extract the general conclusions to be deduced from the observations becomes of greater importance than merely to add to the number of ascertained facts. In a book of about four hundred pages Mr. Harker endeavours to meet this demand, and has covered so wide a range and compressed so much information into this brief space that he has achieved a very large measure of success.

The work is confined to the investigation of the principles of igneous petrology, and the metamorphic and sedimentary rocks are excluded from its scope. The title fairly expresses the aims of the book; it is an attempt to treat of igneous rocks in the manner of natural history, taking account not only of their minute anatomy and structure, but also of their distribution, their range in time, and their genetic associations. Of late years there has been a plethora of unnatural systems of petrology, based on purely arbitrary lines. On the best known of these (the "quantitative classification") the author passes severe judgment, and returns to the broader treatment followed by Rosenbusch, Brögger, Judd, and Teall. That combination of geological reasoning with petrological analysis which has always characterised the English school of petrologists finds able expression in the pages of this treatise.

The geographical distribution of recent volcanic rocks is considered in the introductory chapters, and the remarkable association of "Atlantic" and "Pacific" rock types with certain classes of tectonic developments is made the foundation of an appeal for a natural classification. Undoubtedly the facts are most impressive, though we are entirely in the dark regarding their causes; and they afford the clearest indication that in time we shall be in possession of natural systems of petrography. We learn incidentally that the first sketch of this grouping was presented by Mr. Harker, though it has become more generally known through the treatment of Dr. Prior and Prof. Becke. The Tertiary volcanic rocks of the Inner Hebrides are placed among the Pacific types, a conclusion by no means easy to accept, and one which may need to be revised at some future date.

The application of physical chemistry to the crystallisation of magmas is taken up in considerable detail. This part of the book is practically a summary of Prof. Vogt's papers, and leaves nothing to be desired in lucidity of exposition and accuracy of statement. For students it will be of the greatest value, as the original memoirs are loaded with detail, and much too voluminous for their use, and no satisfactory account of them has hitherto appeared in English. We must confess, however, to a certain feeling of disappointment in reading them, a sense of incompleteness. The *a priori* principles are laid down in a very satisfactory fashion, but the applicability of these principles to the actual concrete facts of rock structure and history, which we had a right to expect from a geologist of Mr. Harker's wide experience, is dismissed with scant treatment. The difficulty of interpreting the history of crystallisation in the commonest rocks in terms of the theoretical principles laid down is sure to face the student at an early stage in his studies. We miss in particular any reference to the work of Schreinemaker, who has proved by analytical investigations that in a solution of three minerals in one another, of which two can form mixed crystals, while the third is independent, there are many possible schemes of crystallisation; one mineral may separate out completely at an early stage, and the crystallisation of any substance may be interrupted or repeated. If there are more components, or if we allow for the influence of dissolved gases in the magma, the problem becomes much more complicated; but it is a relief to find that as the theory is better understood the discrepancies between it and the observed facts seem to diminish.

The subject of "hybridism," or mixed rocks, is discussed in a brief chapter, which sums up in admirable fashion the results of the author's work in this difficult field. He takes a middle position between the schools of petrology which deny that igneous rocks dissolve sediments or older rocks with which they come into contact, and those which hold that such processes go on on a large scale, and that many rocks generally regarded as of normal types are thus produced. Mr. Harker's field work enables him to speak on this subject with great authority, and his conclusions are so moderate and so firmly based on sound evidence that he carries us with him in all that he says. There is also a chapter on magmatic differentiation, a subject on which it does not seem possible to say anything that is new, and a very interesting account of the mutual relations of associated igneous rocks which, in our opinion, is the best in the volume. The curves drawn on a very simple graphic system show the variation in the components of allied rock types, and are convincing that some general principles must underlie the facts, though as yet we have been unable to grasp them. The final chapter on classification is unexpectedly brief, and contains an admission that existing systems are merely temporary stop-gaps, and a satisfactory classification must traverse the lines of all current groupings, and will require an entirely new nomenclature. To us this appears unduly pessimistic, and we believe rather that in petrology as in other sciences the future will be the child of the past, and that real progress will not involve the demolition of the older systems, but will include them while giving them a

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sounder basis to rest upon. The book contains two beautiful photographic plates of active volcanoes, and a large number of useful illustrations; in print, paper, and binding it will meet the approval of every book-lover. J. S. F.

A POPULAR MAMMAL BOOK.

Wild Beasts of the World. By Frank Finn. Pp. viii+188; illustrated. (London and Edinburgh: T. C. and E. C. Jack, 1908–9.) Price 17s. net.

THE favourable opinion we formed of Mr. Finn's work when the first part was noticed last year in NATURE we are pleased to be able to endorse now that the complete volume is before us. The book is confessedly a thoroughly popular one, and, therefore, ought to be judged solely from that standard; and from that point of view it may be pronounced a decided success. The author's style of writing is bright and attractive; and in the main his descriptions appear correct and up to date. Mr. Finn has not overloaded his text with names of naturalists and observers about whom the public knows little or nothing; and he has, in our opinion for the most part rightly, altogether ignored subspecies. As regards nomenclature, the author will have nothing to do with modern innovations and changes, and we accordingly find the baboons (and not the flying-lemur) appearing under their old title of Cynocephalus, and the fox as *Canis vulpes*. The fact that such names still dominate in popular literature suggests that they should not, as is now too much the fashion, be ignored in our museums, which are primarily popular institutions.

Mr. Finn appears to take as his texts the hundred mammals represented in the coloured plates, as the descriptions of all these are printed in larger type than is conceded to many of the others noticed. Personally we are not enamoured of this plan, as it suggests that the species to which large type is accorded are of more importance than the rest; but this point is not one affecting the character of the work as a whole.

The coloured plates form, of course, the characteristic of the volume which will appeal most strongly to the general public; and for these illustrations—the only ones in the book—we have in the main nothing but commendation, although some appear rather too brilliantly coloured. A few, moreover, do not indicate important details—notably the one of the hamster, in which the dorsal gland-patch is not shown. The one serious error in the illustrations occurs in part xii., where the plate lettered Marco Polo's wild sheep really represents the true argali (*Ovis ammon*); and there is no excuse for this, as the figures, if we mistake not, have been drawn from the mounted specimens in the British Museum. Nor is this all, for, whereas the figure in the foreground depicts, as we have said, the true Altai argali, the one in the middle distance is taken from its Tian Shan representative. In the concluding part we notice that the plate of the platypus shows the web of the forefoot fully extended when the animal is on land, in place of being folded beneath the palm, as it must be in order that the creature should get a foothold.

Misprints and other errors in the text appear to be few, but we notice on p. 47 *Mipsiprymnus* for *hypsiprymnus*. In the account of the Derbian eland no mention is made of the fact that the species occurs in the Bahr el Ghazal; while the occurrence of the water-chevrotain in East Central Africa is ignored. The old error as to female takin-horns differing in form from those of the male is also repeated.

Most of these are, however, but trifling errors, which detract but little from a work worthy in the main of high praise. R. L.

APPLIED MECHANICS.

(1) *Applied Mechanics for Engineers.* A Text-book for Engineering Students. By E. L. Hancock. Pp. xi+385. (New York: The Macmillan Co., 1909; London: Macmillan and Co., Ltd.) Price 8s. 6d. net.

(2) *Machines—Outils, Outillage, Verificateurs.* By P. Gorgeu. Pp. 232. (Paris: Gauthier-Villars, 1909.) Price 7 francs, 50 centimes.

(1) THIS book is intended to be a text-book for engineering students during the first year of their course, and the examples selected to illustrate the principles discussed are, therefore, mainly such as are likely to be met with in practical engineering work. To facilitate the working out of the numerical problems, of which there are nearly 300 scattered through the book, the author has printed in the form of five appendices a series of tables including hyperbolic functions, logarithms of numbers, trigonometrical functions, squares, cubes, square roots, conversion tables, &c.; it is very problematic as to how often such tables incorporated in a text-book are of use to the student—it is much more convenient for him to have a small thin book of mathematical tables, and there are several such books now available, which he can carry about with him in his pocket, and refer to whenever calculations have to be made.

Two very complete chapters are those devoted to centre of gravity and moment of inertia; the application of Simpson's rule to the finding of the area and centre of gravity of rail and similar sections is fully discussed, and the whole subject of the determination of moments of inertia of various standard sections is treated very fully, both by analytical and graphical methods: this is a matter of considerable interest to engineers engaged in structural design work. Another chapter which will be found of use by the engineer in practice as well as by the young student is that dealing with the dynamics of machinery: after dealing with such usual problems as those of the flywheel and connecting-rod in a reciprocating engine, a number of sections is devoted to the gyroscope, and to its application to the mono-rail and similar devices.

The last chapter in the book treats of impact in a more satisfactory manner than is usually the case in text-books on mechanics. The book is certain to prove a useful one to all those who are engaged in teaching the subject of mechanics to engineering students, and the number of well-selected examples makes it a particularly satisfactory book for the student himself. Many young engineers are far away from help in matters of this nature, and have to depend upon their own resources—it is essential in such a case that they should have a large number of practical problems to work through in order to familiarise themselves with the principles underlying each branch of the subject.

(2) This book has been written specially for artillery officers detailed for duty in ordnance factories; it is copiously illustrated, and special attention has been given to the relative advantages and disadvantages of different types of machine tools, and to different methods of transmitting motion to the tools.

The first section is devoted to such details as the transmission of motion from one shaft to another by belting and gearing, quick return motions, cams, sliding pairs, turning pairs, and screw pairs, and in each case brief notes are given as to the important points to which attention should be paid in order to secure good results and to maintain all working parts in good order.

The second section deals with all the more important machine tools which are to be found in a modern workshop; in each case a regular order of treatment is followed—first the parts exterior to the machine itself and transmitting motion to it are discussed, and then in order the links in the machine receiving this motion, the links of the machine transmitting movement to the work, the links of the machine transmitting movement to the cutting tool, and lastly any other specialised link, and the frame. This is a method of treatment suitable not only for the non-technical student, but also for students who are just beginning the study of machines and machine tools, and the illustrations, which form a special feature of the book, are so arranged that the reader has no difficulty in finding at once in any of the figures the link of the machine which is described in any particular paragraph of the written description of the machine.

The third section deals with the cutting tools used in the various types of machine tools, methods of tempering, angles for the cutting edge for different classes of work, methods of lubrication, and speed of cutting are all discussed in detail, and a few paragraphs are devoted to the employment of the new high-speed steels.

In view of the fact that interchangeability of parts is now so important in all cases where large numbers of similar machines are constructed, the fourth section is entirely given up to an account of the construction and use of various types of gauges, with a series of useful notes on the precautions which must be adopted to ensure that their employment shall secure the desired result. The book should be consulted by all those who are engaged in the design of machine tools. T. H. B.

A BELGIAN BOTANIST.

Notice sur Léo Errera. By L. Fredericq and J. Massart. Pp. 153. (Bruxelles: H. Lamertin; London: Williams and Norgate, 1908.)

Recueil d'Œuvres de Léo Errera. Vols. i. and ii. Botanique générale. Pp. iv+318 and v+341. Vol. iii. Mélanges Vers et Prose. Pp. xiv+222. (Bruxelles: H. Lamertin; London: Williams and Norgate, 1908–9.)

IT would be difficult to overestimate the influence of the two great German professors, Anton De Bary and Julius Sachs, on the progress of botany. At a time when many fundamental ideas were only beginning to take shape, these advanced workers and leaders of thought attracted a succession of brilliant students from many European countries, who absorbed in Strassburg and Würzburg the doctrines and inspirations of their masters, and eventually spread abroad the new theories and conceptions that are now regarded as the foundations of botanical science. Amongst this band of eager students was the Belgian, Léo Errera, who entered first De Bary's laboratory in 1897, and subsequently sought further experience under the tutelage of Sachs. Two important results can be traced to these courses of foreign study. In the first place, intercourse with such gifted teachers and with brilliant colleagues helped to stimulate the energies of an already keen enthusiast, and to pave the way for future friendships and associations. In the second place, his interests were diverted from systematic to chemico-physiological botany, which became one of the chief lines of research at the University of Brussels.

The first of his primary contributions to science was the paper on glycogen in the Mucorineæ; this was the outcome of research in De Bary and Hoppe-Seyler's laboratories, and required a profound knowledge of the two sciences of botany and chemistry. It was followed by other papers on the same and other physiological subjects published by himself or his students. Prof. Errera was also well versed in mathematics and physics, evidence of which is furnished by the course of molecular physiology prepared for his advanced students. The researches connected with glycogen and the localisation of alkaloids, the papers on the application of physical chemistry to the elementary phenomena of cells, the relations of flowers and insects, and the defensive structures of plants, may be regarded as his chief contributions to botany.

As a professor, Errera took the keenest interest in his students, and spared no pains to stimulate their energies towards the acquirement of knowledge and the prosecution of research. At the time when practical courses were not yet customary he initiated a course which was first held in two small rooms in the gardens, and later in a more spacious laboratory provided at his own expense in a neighbouring building. The biography compiled by two of his former students bears testimony to the enthusiasm he inspired, and provides a realistic picture of his varied talents. He was an accomplished linguist, an excellent lecturer, and an entertaining companion.

The papers on general botany collected in the two volumes noted above are of a popular nature, as his more technical contributions have been published in the *Recueil de l'Institut botanique de l'Université de Bruxelles.* The first is a letter describing the vegetation in the neighbourhood of Nice, written when he was sixteen years old. The article on the structure and methods of fertilisation of flowers appeared four years later; it was inspired by Charles Darwin's work, and the introductory quotation from the "Origin of Species," taken in conjunction with his essay on Darwinism, is worth reproducing:—"Whoever is led to believe that species are mutable will do good service by conscientiously expressing his convictions." The article is, to a large extent, an account of contemporary investigation, but includes original notes on the oxlip and the genus Pentstemon. The essay entitled "Une Leçon élémentaire sur le Darwinisme" was revised in 1903, after the publication of de Vries's book. Errera fully accepts the mutation theory, regarding it as an amplification, and not a contradiction, of the selection theory. The references in this paper to Dr. Scott's work on Cheirostrobus and the joint communication by Drs. Scott and Oliver on Lagenostoma will serve to indicate how the author incorporated the very latest results into his teaching.

The most interesting part of the third volume, containing miscellaneous verse and prose, will be found in the collection of extracts and aphorisms. Here is an epigram that will be appreciated by philosophers generally:—"La vérité est sur une courbe dont notre ésprit suit eternellement l'asymptote." The authors of the biography are to be congratulated on presenting such an interesting account of the brilliant alumnus of Brussels University. The papers are worthy of consultation, not alone for the facts contained, but also for style and arrangement.

OUR BOOK SHELF.

An Atlas of Skiagrams, illustrating the Development of the Teeth, with Explanatory Text. By Dr. J. Symington, F.R.S., and Dr. J. C. Rankin. Pp. 47; pl. xii. (London: Longmans, Green and Co., 1908.) Price 10*s*. 6*d*. net.

THE difficulty of cutting sections comprising both soft and highly calcified parts without causing displacements, and the further trouble of piecing together the disposition of parts in a large number of serial sections so as to reconstruct a model in the solid, gives to skiagrams an especial value, as being a representation of the relations of the developing teeth to one another and to the jaws which is beyond suspicion of disturbance. Certain difficulties arising from the teeth being disposed in an arch were very successfully met by the authors, who resorted to tipping the back of the skull upwards to a uniform extent in all cases, namely, raising the back about 30 degrees, and by this method the shadows of the front teeth were separately projected and the overlapping of the shadows to a great extent avoided. The skulls used were divided into halves, and the right and left sides both presented in nearly every case where the skulls used were more than seven years of age; but in the younger ones, no difference being found between the two sides, only one is presented.

The ages of the subjects used range from birth to adult life, and twenty-three skiagrams are given which illustrate the calcification of the temporary teeth and their change to the successional set; amongst other points clearly shown, the extent of calcification in each tooth, at each age, a point sometimes of medicolegal importance, is well seen. Some points in the relation of the growth of the jaws to the development of the teeth can be advantageously studied in these skiagrams, as well as the relation of the developing teeth to the antrum. Inasmuch, however, as the walls of the antrum cannot always be very clearly traced in the midst of shadows cast by other parts of the upper jaws, the anatomy of the antrum is also illustrated by drawings made subsequently from the same specimens, the technique adopted being to harden the tissues in formol, and then to chip away as much of the bone as could be removed without destroying all support. The lining membrane so treated becomes sufficiently firm to stand alone and retain its shape, and the dissections made were carefully drawn. These figures include also the accessory sinuses. The authors may be congratulated upon having produced an atlas which is of the greatest service in adding to the accuracy of our knowledge of the development of the teeth and of their relations to the parts about them.

Mineralogie und Geologie für schweizerische Mittelschulen. By Dr. Hans Frey. Dritte Auflage. Pp. iv+234. (Vienna: F. Tempsky; Leipzig: G. Freytag, 1909.) Price 2.75 marks.

THIS work, which has evidently been successful, is of the type commonly used in German-speaking schools, and makes no special appeal to the beginner's interest in field-observation, or to the splendid object-lessons ranged around him in his native land of Switzerland. A number of Swiss illustrations are, however, inserted, and the passages on mountain-building and the Alpine lakes embody considerations raised in recent times. To a British mind the mineralogical section will seem to contain far too much in a small compass, if the course is to be gone through systematically before the pupil enters on his collegiate years. It occupies half the book, and is followed by a petrographic chapter, which similarly bears traces of having been brought somewhat hesitatingly towards modern modes of statement and classification.

The section on historical geology, perhaps in accordance with a settled syllabus, is limited to thirty-four pages, and the illustrations of fossils are given without any explanation as to the nature of the organisms. In these circumstances, the generic and specific names are worse than useless; they need, moreover, some revision and press correction. A great opportunity still remains for making the mineralogy and geology of Switzerland serve as an introduction to these sciences, and for letting the land itself speak to the pupil, before he becomes entangled in the strings of facts which are supposed to be inseparable from a scientific education. G. A. J. C.

Gilbert White and Selborne. By Henry C. Shelley. Illustrated from photographs by the author. Pp. xvi+226. (London: T. Werner Laurie, 1909.) Price 6*s*. net.

THIS little book is not badly done so far as it goes, but there is nothing in it that has not often been said before; the photographs are good, but of quite familiar objects. The one innovation consists in eking out a volume offered at six shillings by "Cameos from the Natural History of Selborne," which occupy fifty of these meagre pages: a serious literary blunder, to use a mild word. The six shillings might be much better spent in the purchase of an edition of the famous book, which is much talked of but probably little read.

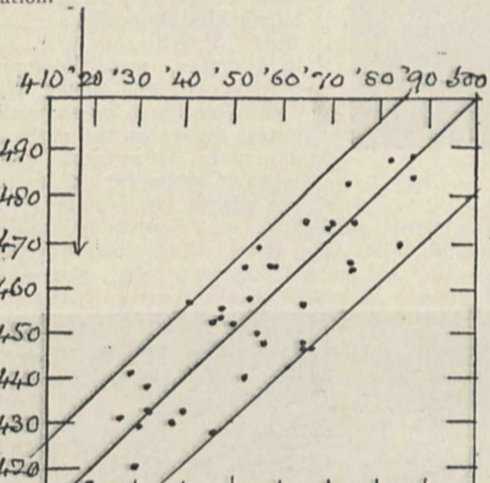
LETTERS TO THE EDITOR.

[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 Summer Season of 1909.

IN endeavouring to estimate the character of a coming season, the following method is, I think, often serviceable. Let us take, as a concrete case, the annual numbers of very hot days at Greenwich (80° or more) from 1841 to 1908. Add these in the thirty years ending 1870, 1871, 1872, &c. Then compare each sum with the next by the dot method; where each dot represents one value by the horizontal scale, and the next by the vertical. A line may be drawn connecting points of intersection of lines (horizontal and vertical) from equal numbers in the two scales, and two others roughly parallel with it (as shown).

Now the last value, previous to this summer—the sum, that is, of the thirty years ending 1908—is 417. Find this in the horizontal scale, and consider where the next dot is likely to go. It would hardly be higher than (say) the level of 433. Now we know the numbers of those days in twenty-nine out of the thirty summers ending 1909; their sum is 416. Deducting 416 from 433 leaves 17; and we infer that this season would probably not have more than seventeen of those hot days (which is only two more than the average). The season has, so far, proved a very cool one (August 4). This method is obviously capable of wide application.



A similar conclusion seems to be arrived at by a comparison of Greenwich and Rothesay weather. It appears (whatever the explanation) that when the year's rainfall at Rothesay has exceeded 55 inches (last year had 56), the following summer at Greenwich has never been very warm. We may tabulate the cases (eleven in number, 1841–1907) as follows:—

	Rothesay Rf. in.	Greenwich days with 80° or more following summer	Relation to av. (15)
(1) 1872	70·2	16	+ 1
(2) 1877	68·6	11	− 4
(3) 1841	65·9	17	+ 2
(4) 1903	61·6	16	+ 1
(5) 1882	59·6	7	− 8
(6) 1862	59·5	13	− 2
(7) 1866	58·7	9	− 6
(8) 1907	58·5	8	− 7
(9) 1868	57·2	14	− 1
(10) 1861	56·3	1	− 14
(11) 1906	56·3	2	− 13
		Av. 10·4	

That is, eight cool summers, three slightly warm, and the hottest with seventeen of those days. It seemed not unreasonable to apply this "rule-of-thumb" (if it is to be so called) to the present season, following on a Rothesay year, which would fall to be added to the above list.

Once more; the summer season of 1879 is well remembered as a singularly cold one. There were only thirty days with 70° or more, and one with 80° or more (the averages being 77 and 15 respectively); and now, at thirty years' interval, we have another very cold summer.

Suppose we compare each summer with the thirtieth after, in respect of those very hot days (80° or more). We can carry the comparison obviously up to 1878 (that year compared with 1908).

It would appear that, in the case of very cold and very warm summers, there is some tendency for the thirtieth after to be of like sign in relation to the average.

Thus the six coldest, in ascending order (0 to 6 hot days), are 1860, 1862, 1841, 1853, 1855, 1845; in each case but one the thirtieth season after was cold, and that one was average.

The six hottest, in descending order (40 to 27 hot days), are 1868, 1857, 1859, 1846, 1876, 1870; in each case but one (again average) the thirtieth season after was hot. The season of 1909 seems likely to conform to this.

ALEX. B. MACDOWALL.

P.S. (September 13).—There have been, so far, nine of those very hot days (three in May, six in August), which is probably the year's total, or near it.

A New Mineral from a Gold-washing Locality in the Ural Mountains.

SOME time ago I acquired through a friend two small glass tubes, together containing about 5 grams of a bright greyish-yellow crystalline powder.

The manager of the gold workings in question noticed several years ago in his troughs minute quantities of the dust referred to, and commenced to collect it, but in spite of the greatest care he was not able to find more than about 10 grams during the subsequent years.

The separation of the dust has been made easier through the specific gravity of the microscopic crystals being =9. Various analyses made proved the dust to consist of about 98·5 per cent. tantalum and about 1·5 per cent. niobium, with 0·001 per cent. manganese. We have therefore a new mineral, namely, native tantalum.

During the last six months no more traces of the mineral have been found, notwithstanding the greatest possible care taken to find more. It seems to have been here an instance of an isolated formation, but it is not impossible that the same mineral may be found elsewhere, associated with gold and platinum, but is overlooked owing to the small quantity and the fact that it has a lower specific gravity than gold or platinum.

Perhaps this information may be of interest to those associated with gold or platinum workings, and may induce them to look out for this new mineral, when it is not improbable there may be found other native metals as well.

Newcastle-upon-Tyne. P. WALTHER.

The Benham Top.

IN confirmation of Mr. F. Peake Sexton's contention in NATURE of September 2 (p. 275), that irradiation plays no appreciable part in the necessity for thin lines on the Benham top, I may add that the colours are equally well seen when the top is viewed (1) through a narrow diaphragm held close to the eye; (2) through a magnifying lens; (3) in the monochromatic light of the sodium flame.

My only objection to Mr. Sexton's theory was at first the brilliancy of the colours in the light of the sodium flame, but this difficulty at once disappeared when Mr. Sexton pointed out that though blue objects cannot be seen as such in that light (because there are no blue rays present for them to reflect), it by no means follows that the nerve centre for blue cannot be stimulated by the light of a sodium flame. It will be seen, on reflection, that quite different phenomena are involved in the two cases, and, this understood, there seems to be no difficulty in accepting Mr. Peake Sexton's theory, which is substantially similar to that of Prof. Liveing, made at the time the top first appeared, though Prof. Liveing did not seem to realise that the case of the sodium flame presented no real difficulty, and he suggested that the colours seen in that light were due to the fact that it is not absolutely monochromatic—a quite unnecessary contention.

Colchester, September 8. CHARLES E. BENHAM.

THE APPROACHING OPPOSITION OF MARS.

THE planet Mars is now a conspicuous object in the evening sky, its ruddy, brilliant disc appearing just below the great square of Pegasus, and astronomers the world over are once more seizing the opportunities presented by a favourable opposition for the further solution of the Martian enigma. The actual opposition will not take place until September 23d. 22h., or 10 a.m. on September 24, civil date.

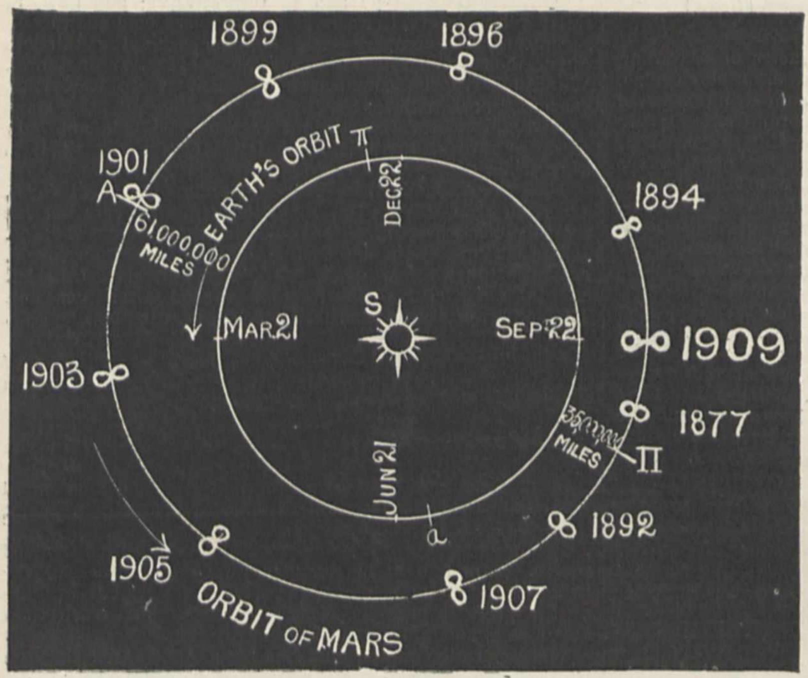
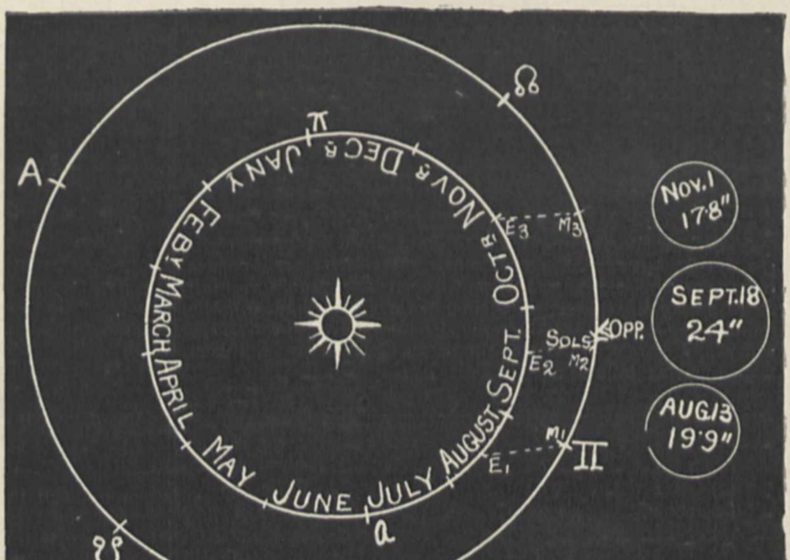


Fig. 1.

As Prof. Lowell says in his classical memoir on Mars, "Study of Mars at one opposition is material to its study at the next. . . . At any one opposition we may scan Mars but for a few months through only a fraction of its circuit round the sun." Therefore, no opportunities may be missed by the students of the ruddy planet, whenever, and under whatever conditions, an opposition takes place. But only at one opposition in every seven, or about once every fifteen years, are the conditions so favourable as at present; Figs. 1 and 2 show this diagrammatically. The orbits of the earth and Mars are drawn to scale, but as eccentric circles, and from Fig. 1 it will be seen that the opposition of this month will be, as regards the distance separating the two planets, the most favourable we have experienced since 1892. Owing to the eccentricity of the planet's orbit, the distance between the earth and Mars, when at an opposition, may range from 61,000,000 to 35,000,000 miles, the corresponding range of the apparent diameter being 13″ to 25″. The most favourable oppositions occur when Mars is near its perihelion (Π, Figs. 1 and 2), with the earth near its aphelion (α), point. The ideal condition would be for opposition to take place about the last week in August, whilst the most unfavourable conditions would obtain if it occurred about the third week in February; thus the opposition of 1877 was the most favourable during last century, except that of 1845, whilst that of 1901, February 21, was about as unfavourable as is possible.

The advantage of proximity was well illustrated in 1877, when Asaph Hall discovered the two Laputan satellites, and Schiaparelli first observed the much-discussed *canali*.

On September 23, when at opposition, Mars will be about 36·4 million miles from the earth, but the nearest approach of the two bodies will take place on September 18, when the distance separating them (E_2–M_2, Fig. 2) will be about 160,000 miles less. After the opposition, as the planet lags behind the earth, as shown in Fig. 2, the distance will continue to increase, and the apparent diameter of the planet will, of course, decrease, as shown by the circles drawn on the right of the diagram. These circles show the relative apparent diameter of the planet on August 13, when Mars is at perihelion, on September 18, when at least distance from the earth, and on November 1, when a substantial increase in the distance



IG. 2.

separating the two bodies will have taken place. The following are the apparent diameters of the planet at different epochs during the present opposition:—September 1, 22·8″; September 18, 24″; September 23 (opposition), 23·9″; October 1, 23·3″; November 1, 17·8″; December 1, 12·7″. This means that on September 18, an observer using a power of ×80 would see Mars on the same scale as a naked-eye observer sees the moon; the conditions of "seeing" would be worse. Taking another illustration, a land area of about the size of Ireland would, roughly speaking, appear as a spot of 1·3″ diameter, or a little longer than 1/1500th of the apparent diameter of the full moon.

Whilst the distance of the planet is an important factor in determining the value of the observing conditions at an opposition, it is by no means the sole factor; the altitude of the planet above the horizon makes or mars the conditions for the users of large instruments searching for minute detail. Thus, although the opposition of 1892 produced a more favourable distance-condition than that of 1894 (see Fig. 1), the observing conditions at the latter were not inferior, because of the higher culmination of the planet. At the present opposition, the declination of Mars is 4° S., and this means that for observers in our latitude (51° 30′) the meridian altitude will not exceed 35°; but this is a great improvement on the conditions in 1907, when the corresponding altitude was only 10°, and when, even from Flagstaff, Prof. Lowell found it desirable to send an expedition to the Andes for the observation of the planet. During the present opposition the meridian altitude at Flagstaff will be more than 50°.

As at all favourable oppositions, taking place about August, the south pole of Mars is now tilted earthwards, the earth, at the date of opposition, being about 20° below the plane of the planet's equator. Therefore the southern hemisphere will be observed, and as the summer solstice of this hemisphere, as shown in Fig. 2, occurs but a few days before opposition, the southern snowcap is in the process of dissolution, and changes due to the melting of the snow are taking place. Already such phenomena have been recorded by MM. Desloges and Jonckheere, among others. As the rotation-periods of the earth and Mars are approximately equal, the same regions can be observed on consecutive nights. On September 19 the Syrtis Major region will be in view, and on September 27 the region of the Mare Cimmerium.

Probably at no opposition since the time that Fontana suspected markings on the ruddy planet, in 1636, has the status of areographers been so critical as at the present juncture. Thanks to the persistent labours and unswerving faith of a few observers, of whom Prof. Lowell is the foremost, the question as to the subjective reality of the *canali* discovered by Schiaparelli in 1877 may be considered as settled. Whether one follows Prof. Lowell's lead in the matter of "artificial, irrigating waterways" or not, there can remain but little, if any, doubt that these long, straight channels do exist. In describing his observations, made at Trincomali, Ceylon, during the unfavourable opposition of 1903 (see Fig. 1), when the apparent diameter of the planet was but 14·6″, the late Major Molesworth said[1]:—"Personally, I am quite convinced of the reality of the great majority of the so-called canals: I think I could convince the most sceptical on this point if they could only have spent an hour or two at my telescope on some of the perfect nights in March and April this year." Major Molesworth used a 12¼-inch Calver reflector, with a power of 450. Numerous observers, and the Flagstaff photographs, have also testified as to the gemination of these features. Not only do these canals exist, but, in the opinion of many experienced observers, they also suffer changes which show a dependence on the seasonal changes of the planet.

Having settled the existence of the "canals," it became necessary to account for the changes, and, in one essential, this question remained more or less open until the opposition of 1907. With regard to the polar caps, Herschel's observations enforced the natural conclusion that their changes were due to the accumulation and dissipation of "snow" as the Martian winters waxed and waned. This coincidence of snowcap and season was not to be denied, and in the Martian spring, at the opposition of 1892, Prof. W. H. Pickering observed the disappearance of some 1,600,000 square miles of the southern snowcap, an area about the size of India, in a period of thirty-three days. But there still remained the one essential factor, that was the proof that this "snow" was really frozen water; that the Martian atmosphere contained water-vapour sufficient to produce these effects. On this point the different observers were at issue.

Beer and Mädler, during 1830–9, found that occasionally certain permanent features of the planet's landscape were blurred, as though by passing cloud and mist. During the favourable opposition of 1862, Lockyer's observations led to the definite conclusion that "the daily—nay, *hourly*—changes in the detail and in the tones of the different parts of the planet"[1] were caused by the transit of clouds over the various features.

"Clouds and mists" and "polar snows" inevitably suggest to the terrestrian the presence of water, hence a *raison d'être* for the canals, and the spectroscopic evidence adduced by Huggins and Vogel went to confirm the suggestion. But with the spectroscopic equipment of the Lick Observatory at their disposal, Campbell and Keeler could find no evidence for water-vapour in the planet's atmosphere, and the critics of a "terrestrial" Mars suggested that the snowcaps might be caused by the solidification and deposition of some other compound, such as carbon dioxide.

However, the spectrograms obtained by Mr. Slipher at the last opposition, 1907, afford, according to our present view, incontrovertible evidence that the atmosphere of Mars does contain a detectable quantity of water-vapour (see NATURE, vol. lxxvii., p. 442, March 12, 1908). Prof. Very estimates that at the time the spectrograms were taken, the Martian atmosphere contained sufficient precipitable water to give an average layer 14 mm. deep, or about one-third or one-fourth that in the earth's atmosphere. Nor is water-vapour the only familiar atmospheric constituent which has been shown to be present by the Lowell Observatory spectra. When Mr. Slipher described[2] the 1907 spectra, he explained the difficulty of detecting the free oxygen constituent of the Martian atmosphere, viz., the probable relatively slight increase in intensity, of the oxygen bands, produced by adding the absorption of a thin (Martian) atmosphere to that of a dense (terrestrial) atmosphere, but expressed the opinion that "its detection need not be considered impossible."

A recent message from the Kiel Centralstelle, dated September 10, informs us that Prof. Very's measures of the Lowell Observatory spectrograms—which show the spectra of the moon and Mars photographed side by side when the respective objects are at equal altitudes—show that oxygen is present in the atmosphere of Mars; the relative intensification of the oxygen band *b*, in the planet's spectrum, is stated to be eight times the probable error of the measures. Therefore, although the details are yet to come, it appears fairly

[1] Monthly Notices, vol. lxv., No. 8, p. 839, 1905.

[1] Memoirs R.A.S., vol. xxxii., p. 179, 1863.

[2] *Astrophysical Journal*, vol. xxviii., p. 404, 1908.

safe to assume that not only water-vapour, but oxygen also, exists in the Martian atmosphere.

Thus we arrive at the present opposition with the knowledge that a familiar compound, capable of forming snowcaps, of filling canals, and of being pumped in order to irrigate the pastures of a thirsty landscape, exists on Mars, and is accompanied by that element which we terrestrians look upon as another essential for the existence of animal life; and crucial difficulties in the "habitability" theory have been removed. Close, persistent, and world-wide scrutiny, at this favourable epoch, should lead to further elucidation of the enigma, and enable us to "reconstruct" a being and a vegetation capable of existing there.

An idea which has caught the popular fancy is that of signalling to Mars, but as the earth, from the planet, would be in the glare of the sun and would subtend, even at the impossible moment of opposition, an angle of less than 50″—of the same order as the apparent diameter of Jupiter at his recent opposition—to say nothing of the questionable transparency of our thicker atmosphere, this problem has not yet entered the province of practical astronomy.

WILLIAM E. ROLSTON.

POLAR EXPEDITIONS AND OBSERVATIONS.

THE position and prospects of polar exploration have been given great attention in the daily Press during the last few days. No precise information as to Dr. Cook's journey to the North Pole has yet been published, but the general narrative of Commander Peary's expedition leaves little room for doubt that Commander Peary reached the neighbourhood of the pole, and probably the pole itself, though an element of uncertainty must exist until his observations for latitude are examined critically. The Berlin correspondent of the *Times* reports that an executive committee for a Zeppelin polar expedition has been formed, the object of the expedition being defined as "the scientific investigation by means of the dirigible airship of the unknown Polar Arctic Sea and the development of the dirigible airship for the carrying out of scientific labours." Announcement has also just been made that a British Antarctic expedition will start next August under Captain R. F. Scott, who commanded the National Antarctic Expedition of 1900–4, with the object of reaching the South Pole.

As all the world knows, Mr. Shackleton's record of this year has given Great Britain the premier position in Antarctic exploration, and an earnest desire is felt by British explorers to place to the credit of this country the feat of first reaching the South Pole. McMurdo Sound has in the past been used as the base for British South Polar expeditions, but it is proposed on the next journey to establish a second base in King Edward VII. Land, 400 miles to the east of McMurdo Sound. The track to the pole from the new base may be expected to include phases similar to those met with in travelling from McMurdo Sound, but it is anticipated it will continue longer on the sea-level, meet the mountains nearer the pole, and consequently leave a shorter journey on the high inland plateau. The distance to be covered is in all some 1500 miles, for which 150 days are available. The plan for the journey to the pole from King Edward VII. Land includes the use of three means of sledge traction: ponies, a dog team with a relay of men, and motor sledges.

The scientific objects of Captain Scott's expedition are stated to be as follows:—(1) Geographical.—To explore King Edward VII. Land, to throw further light on the nature and extent of the great Barrier ice formation, and to continue the survey of the high mountainous region of Victoria Land. (2) Geological.—To examine the entirely unknown region of King Edward VII. Land and continue the survey of the rocks of Victoria Land. (3) Meteorological.—To obtain synchronous observations at two fixed stations, as well as the weather records of sledge journeys. (4) Magnetic.—To duplicate the records of the elements made by the *Discovery* expedition with magnetographs. The comparison should throw most important light on secular changes. (5) Miscellaneous.—In addition, attention will be paid to the study of marine biology at both stations and in the ship, and the examination of physical phenomena will be continued.

It is estimated that an expedition of the kind projected will cost at least 40,000*l.*, and towards this sum considerable amounts have been given already. An appeal has been made to the public, and it is hoped that no difficulty will be experienced in raising the necessary money for the accomplishment of what will in any case include valuable scientific work.

The full narrative of Commander Peary's expedition to the North Pole appeared in the *Times* of September 11 and 13, and occupied six columns. By permission of the editor we are able to give a summary of this account of the journey and the observations made. The expedition left Etah, Greenland, on August 18, 1908, in the *Roosevelt,* having on board 22 Eskimo men, 17 women, 236 dogs, and about 40 walrus. Cape Sheridan was reached on September 5 and winter quarters were established there. Sledge loads of supplies were then taken to Cape Belknap, Porter Bay and other stages up to Cape Columbia, where Prof. McMillan obtained a month of tidal observations during November and December. Tidal and meteorological observations were also made at Cape Bryant, and explorations were carried on.

The expedition started for the north from Cape Columbia in several divisions at the end of February of this year. Latitude 83° 20′ was passed on March 2, and on March 5 "the sun, red and shaped like a football by refraction, just raised itself above the horizon for a few minutes and then disappeared again." The lead, or creek of open water, which was then reached, prevented further movement until March 11, when it was frozen and a start became practicable. The depth of the lead was determined by soundings to be 110 fathoms. On March 14 the lead had been passed, and the temperature was −58° (?) F. Two days later Prof. McMillan had to be sent back to Cape Columbia at once on account of frostbite. "Sounding gave a depth of 825 fathoms. We were over the Continental Shelf, and as I had surmised, the successive leads crossed in the fifth and sixth marches composed the big lead and marked the Continental Shelf."

By an admirable system of advance, main and supporting parties, the expedition moved rapidly north, covering no fewer than fifty minutes of latitude (about 57 miles) in three marches. The fourth supporting party started on the back trail from about latitude 88°, and on April 2 Commander Peary, with his party of Eskimos, moved towards the pole.

In a march of about ten hours the party travelled twenty-five miles and was well beyond the 88th parallel, "with the sun now practically horizontal." Several long marches were accomplished, and one of forty miles in twelve hours. In four days, two degrees of latitude were covered, that is, a distance of about 138 miles. On the last stage of the journey Commander Peary's only companion was an Eskimo. An observation made on April 6 showed that the latitude was 89° 57′, so that the pole had been practically reached. Thirty hours were spent in making observations there and ten miles beyond the camp, and in taking photographs. No land could be seen. The minimum temperature recorded during the thirty hours was −33° and the maximum −12° (?) F. A sounding was made five miles from the camp, but bottom was not touched at 1500 fathoms. The party returned to Cape Columbia on April 23, and to the *Roosevelt* four days later. On July 18 the ship left Cape Sheridan and arrived in Indian Harbour on September 6.

The record of the expedition is a triumph for good organisation and persistent endeavour, and though details of the scientific observations are not yet available, the narrative gives good reason for believing that, so far as the time permitted, some valuable work was accomplished. Commander Peary states that Prof. Marvin and Prof. McMillan both secured numerous observations of tidal and meteorological conditions, as well as other data of scientific interest, while Dr. Goodsell gave special attention to microscopic work.

Commander Peary's achievement has rendered unnecessary any further expedition to reach the North Pole, so that attention may now be concentrated upon systematic scientific work in the region of which a preliminary view has just been taken. Whatever may be the ultimate decision as to relative claims to have been the first to reach the pole, there can be no doubt that the work carried on by the members of Commander Peary's expedition will be of greater value to science than mere observations of latitude taken during a "dash" to the pole. The success of the expedition is associated, however, with a fatal mishap to one of the scientific members. Prof. R. G. Marvin, of Cornell University, was drowned on April 10, forty-five miles north of Cape Columbia, while returning from latitude 86° N. in command of a supporting party. Prof. Marvin was only thirty years of age, and his death has caused great regret.

Though Commander Peary refers in his narrative to observations for latitude made at various points, no particulars are given, but that may be because the narrative was written for the general public. The explorer has had a unique experience in Arctic regions, and when his observations are published they will, it is hoped, show that the instruments used and corrections applied enabled him to determine position with reasonable accuracy. The determination of latitude by observations of the sun is, however, very difficult in latitudes near the poles. Without suggesting that Commander Peary's results may be found to require correction, it is of interest to indicate the conditions of observation in polar regions and the instruments used by some explorers.

LATITUDE OBSERVATIONS IN POLAR REGIONS.

To an explorer situated at one of the poles of the earth, the stars and all other heavenly bodies appear to pass round him in circles parallel to the horizon once in twenty-four hours, and the altitude of any one star is the same at whatever time it might be taken, provided the atmospheric conditions remain unchanged. If an explorer could be at either pole during the winter months, the best proof he could have that he had really reached 90° latitude would be by observations of stars. Should he be able to measure the altitude of a star with a theodolite or sextant and artificial horizon, at not less than 35° above the horizon, and repeat his measurement at regular intervals, say, of three hours, during one complete rotation of the earth, and find the altitude to be the same at every observation, he would certainly be at an extremity of the earth's axis. Should time be pressing, instead of this somewhat lengthy operation he could take observations of different stars one after the other around the horizon, and then if, after applying corrections for refraction and instrumental errors, he found in each case the altitude to be the same as the declination of the star given in the Nautical Almanac or similar publication, he could conclude that he was exactly on a pole of the earth. The former of these two would be the more satisfactory method, because effects of refraction, which is very uncertain in high latitudes, would be eliminated.

But it is usually daylight when the explorer reaches his highest latitude, and the stars are not visible, so here is a practical difficulty in the way of either of these methods. Still, much the same plan could be followed with the sun. If an explorer is exactly at the pole the sun will pass round him in a circle in twenty-four hours, and the only change in its altitude will be due to the change in declination, which is given in the Nautical Almanac for every hour. Should it be found, then, during a series of observations of the sun extending throughout twenty-four hours, or over a number of hours, that the observations changed just the amount of the sun's change in declination for every hour, the only place where the observer could be would be at the pole.

If, instead of the altitude remaining the same, it should, during one rotation of the earth, be found to decrease for twelve hours and then increase for the other twelve, or *vice versa*, it is clear that the latitude would not be 90°, but its value could easily be computed from the observations.

As regards observations for time taken at or near the poles, the ordinary method of taking sets of altitude of east and west stars fails altogether, for the simple reason that the altitude remains practically the same at all times, and it is impossible to state the *exact* instant of time corresponding to a certain altitude. The only satisfactory method of rating a chronometer would be by taking transits of the sun or stars by a theodolite firmly fixed and left in position on a stand. Since all the meridians converge at the poles, there can be no difference of longitude, and another remarkable fact would be that an observer exactly over the North Pole would be facing south whichever way he turned, and this would interfere with his ordinary idea of bearings considerably.

There can be no doubt that the best instrument to take for accurate observations at or near a pole is a good transit theodolite, and altitudes below 30° or so should, if possible, be avoided. With a sextant and artificial horizon, a low altitude, such as 10° or 11° or below, is very satisfactory. In the first place, it is un extremely difficult to make a contact at all, and then the image in the artificial horizon is usually greatly distorted, specially when a glass plate artificial horizon is used, silvered only on the back. But whether the observations are taken with a theodolite or sextant and artificial horizon, it is naturally impossible to expect any result that can be depended on unless a solid foundation exists upon which to level up the theodolite or place the artificial horizon.

To take advantage of the best conditions of the ice and ensure a safe return, a polar explorer endeavours to reach his highest latitude at an early date when the sun's declination is only a few degrees. Thus it was April 7, 1895, when Dr. Nansen arrived at 86° 12·3′ N., and April 25, 1900, when Captain Cagni, of the Duke of the Abruzzi's expedition, reached latitude 86° 34′ N., his farthest north; whilst the two explorers whose names are just now so prominent both announce that they discovered the North Pole in this month.

Although doubtless unavoidable for the reasons stated, these comparatively early dates of reaching high latitudes have great disadvantages so far as observations are concerned. The stars have disappeared, to be seen no more for five or six months, and the sun is so near the horizon, owing to its low declination, that the meridian altitude, upon the measurement of which the latitude usually depends, is not high enough to give a satisfactory result, owing to the uncertainties of the refraction correction, and, if a sextant and artificial horizon are used, to the great difficulty in making the observation at such a low altitude, and unavoidable distortion of the sun's image. For good results it is a maxim with geographical surveyors that no altitude should be taken that is less than 25° or 30°.

A meridian altitude of the sun only a little above 6°, which is what would be observed at the poles on April 6, or between 11° and 12°, which would be the amount for April 21, would not be likely to furnish a very exact latitude, even if taken with a first-rate instrument under favourable climatic conditions, much less so when these are not favourable and when the observations are made with the small portable instruments which alone can be carried by the explorer on a rapid dash to the pole, when every ounce of weight is a serious consideration.

Dr. Nansen, after leaving the *Fram*, took with him on his famous sledge journey a small altazimuth, with 4-inch circles, and a pocket sextant with an arc of 1¾ inches radius, both of which, by means of verniers, read to single minutes. It was with the pocket sextant, however, that his farthest north latitude observation was made, using the natural horizon, and he admits that the result cannot be depended upon to a minute or two.

Captain Cagni observed with a sextant, and in referring to his farthest north latitude, which depended upon an altitude of about 12°, states that he used both the artificial horizon and the natural horizon, which latter was very distinct.

Coming now to the Antarctic regions, Captain Scott's expedition was well provided with instruments, but his highest latitudes on the southern journey were taken with a small theodolite. In the case of this expedition, the dates when the high latitudes were reached were later on in the summer, so that the sun's southern declination, and consequently its meridian altitude, was higher.

This same remark also applies to Mr. Shackleton's recent expedition, for on January 3, when the last observation on his long journey to the south was made, the sun's meridian altitude was about 25° 33′, which resulted in a latitude of 87° 22′, the further distance travelled south of this depending for its measurement chiefly on the sledgeometer, which throughout the journey had been found to agree well with the latitudes observed. On his journey Mr. Shackleton used a 3-inch transit theodolite, reading to single minutes, and the adjustment of which had been thoroughly tested. He also had the advantage of observing on *terra firma* instead of moving ice, so altogether his resulting latitudes doubtless compare very favourably, as regards accuracy, with those of other polar explorers.

As regards the effect of extreme cold on the refraction correction of the altitude, it may be interesting to note that, for an altitude of 11°, there is a difference of just above 1′ for a change of temperature from +50° to −60° F.

Sextant observations taken with a glass plate artificial on moving ice would be most untrustworthy, for, in addition to the probable sources of error already referred to, there may be slow oscillations of the water, tidal or other, that may affect the level of the reflecting surface considerably.

CHEMISTRY IN THE SERVICE OF THE STATE.

It is generally known in chemical circles that Sir Edward Thorpe is relinquishing the post of principal chemist at the Government laboratory, which he has so ably held for the last fifteen years. In the closing paragraphs of the present report[1] he notes that it is the last document of the kind he will have the honour of submitting to the Treasury, and takes the opportunity of directing attention to the great increase which has occurred in the work of the laboratory during the period in question. It appears that the number of samples examined yearly is now more than double what it was fifteen years ago, the actual figures being 76,513 in the year 1894, and 176,935 in 1908–9.

Naturally there is not much of strictly scientific importance to be found in the record of an establishment devoted to "the daily round, the common task" of acting as chemical Abigail to all and sundry Government offices. Yet in its applications of chemical science to civic requirements Sir Edward's department touches the public welfare at many points; and in illustration of this some gleanings from the pages before us are not without interest. For statistics, in which the report abounds, the reader may be referred to the publication itself.

The business of the laboratory is subdivided into three main classes. Articles examined for the two great revenue departments, Customs and Excise, form by far the largest number of samples. A considerable amount of work, however, is submitted by other branches of the executive, especially the Board of Agriculture, the India Office, the Admiralty, the Board of Trade, and the Office of Works. Finally, samples, relatively few in number, but important as being objects of dispute in legal proceedings, are referred to the laboratory for examination under the provisions of the Sale of Food and Drugs Act and the Fertilisers and Feeding Stuffs Act.

In its *rôle* of revenue chemist, the laboratory is required to hold the balance fairly between the Exchequer on the one hand and the maker or importer of taxable commodities on the other. Alcoholic liquors, sugar, tobacco, tea, coffee, and chicory naturally furnish the greater number of samples for analysis, since they are the chief dutiable articles in this country. But in safeguarding the revenue derived from these products it is also necessary to analyse numerous other articles; thus the principal chemist remarks that "the duty on chicory involves the examination of many substances botanically allied to it, such as dandelion and burdock roots." Genuine cider, again, is not liable to import duty, but samples are analysed nevertheless; for "if evidence is found that spirit has been added," the cider comes under the tariff as a preparation containing spirit, and is taxed accordingly. It is noted that a large proportion—more than 13 per cent.—of certain beverages sold as temperance drinks contained an excess of alcohol, the quantity ranging from 3 to 11 per cent. of proof spirit.

Among other miscellaneous matters, an investigation into the character of the spirits usually sold to the labouring populace was undertaken. Such phrases as "adulterated, maddening liquor" are common in the mouth of the well-meaning but uninformed temperance enthusiast. The results of an impartial inquiry, however, lend no support to the charge of adulteration. Samples of whiskey, gin, rum, and brandy were purchased in the ordinary way

[1] Report of the Principal Chemist upon the work of the Government Laboratory for the Year ended March 31, 1909. Cd. 4771. Price 3*d*.

at public-house bars and retail counters in working-class neighbourhoods of London and the principal towns of the United Kingdom, as well as from the booths at fairs and markets in West of Ireland districts. "There was no evidence of any deleterious substance or adulteration of any kind," remarks the principal chemist.

The work done for "other Government departments" covered a very wide range of products. From gold-braid to African coinage; from cordite-jelly to poisoned trout, almost every conceivable variety of article was submitted for analysis. There is an account of feeding-stuffs sold by a firm of millers, and found to consist wholly of sawdust and gypsum; wherefore the millers were mulcted in heavy penalties. There is a story of "a firm of traders doing a considerable business" who were found practising extensive frauds with postage stamps. "Proof of the fraud was given by one of the chemists of the department, first at the Mansion House, and afterwards at the Old Bailey, where the accused persons were duly convicted and sentenced."

Glimpses of tragedy also appear here and there. Thus we read about the analysis of the air from an underground chamber in which a post-office employé had been asphyxiated; and about the examination of a paint which gave off certain fumes, and apparently brought about, indirectly, the electrocution of a workman.

Foodstuffs, of course, figure largely in the report. As regards imported butter, it would appear that the legal proceedings taken three or four years ago have had a beneficial effect in eliminating much of the adulteration that was then practised. A similar result is also recorded in respect of preservatives in cream.

The foregoing are a few examples indicating the nature of the year's work, though not altogether its scope. Questions of brewing and distilling, the use of duty-free alcohol in manufactures, the purity of tobacco, the sale of patent medicines, the efficacy of sheep-dips, the trustworthiness of disinfectants, the materials used in dangerous industries, water supply, and many similar matters were also dealt with, and are duly chronicled in the report.

In relinquishing his post, Sir Edward Thorpe can look back upon fifteen years of eminently useful service to the State. Large and conflicting interests are involved in the duties of his department; and to have held the scales evenly between the claims of the public services on the one hand, and the various sections of the trading community on the other, is no mean achievement. One question, however, suggests itself at this juncture. Is it any longer of public utility to retain the present grouping of what are really several laboratories under one head? Looking at what is done in other countries, should not the Board of Agriculture, for example, have its own separate chemical establishment, with a freer hand for investigation and development than is readily practicable under the present conditions?

C. S.

THE BRITISH ASSOCIATION AT WINNIPEG.

SUBJOINED is a synopsis of grants of money appropriated for scientific purposes by the general committee at the Winnipeg meeting. The names of members entitled to call on the general treasurer for the grants are prefixed to the respective research committees.

Recommended by Council.

	£
Gill, Sir D.—Measurement of Arc in South Africa ...	100
Glazebrook, Dr. R. T.—Electrical Standards Report ...	100
Section A.—Mathematical and Physical Science.	£
Turner, Prof. H. H.—Seismological Observations......	60
Shaw, Dr. W. N.—Upper Atmosphere	25
Preece, Sir W. H.—Magnetic Observations at Falmouth	25
Gill, Sir David—Establishing a Solar Observatory in Australia	50
Section B.—Chemistry.	
Divers, Prof. E.—Study of Hydro-aromatic Substances	25
Armstrong, Prof. H. E.—Dynamic Isomerism	35
Kipping, Prof. F. S.—Transformation of Aromatic Nitramines	15
Kipping, Prof. F. S.—Electro-analysis	10
Section C.—Geology.	
Harker, Dr. A.—Crystalline Rocks of Anglesey	1
Gregory, Prof. J. W.—Faunal Succession in the Carboniferous Limestone in British Isles	10
Tiddeman, R. H.—Erratic Blocks	10
Lapworth, Prof. C.—Palæozoic Rocks	10
Watts, Prof. W. W.—Composition of Charnwood Rocks	2
Watts, Prof. W. W.—Igneous and Associated Sedimentary Rocks of Glensaul	15
Gregory, Prof. J. W.—South African Strata	5
Geikie, Prof.—Geological Photographs	10
Strahan, Dr. A.—Fossils of Midland Counties	25
Section D.—Zoology.	
Woodward, Dr. H.—Index Animalium	75
Hickson, Prof. S. J.—Table at the Zoological Station at Naples	75
Herdman, Prof. W. A.—Hereditary Experiments	15
Shipley, A. E.—Feeding Habits of British Birds	5
Vincent, Dr. Swale—Prairie Fauna	15
Section F.—Economic Science and Statistics.	
Palgrave, R. H. Inglis—Gold Coinage in Circulation in the United Kingdom	6
Cannan, Prof. E.—Amount and Distribution of Income	15
Section G.—Engineering.	
Preece, Sir W. H.—Gaseous Explosions	75
Section H.—Anthropology.	
Munro, Dr. R.—Glastonbury Lake Village	5
Myres, Prof. J. L.—Excavations on Roman Sites in Britain	5
Read, C. H.—Age of Stone Circles	30
Read, C. H.—Anthropological Notes and Queries......	40
Hogarth, D. G.—Researches in Crete	70
Ridgeway, Prof. W.—Neolithic Sites in Greece	5
Section I.—Physiology.	
Schafer, Prof. E. A.—The Ductless Glands	40
Sherrington, Prof. C. S.—Body Metabolism in Cancer	20
Hickson, Prof. S. J.—Table at the Zoological Station at Naples	25
Waller, Dr. A. D.—Electromotive Phenomena in Plants	10
Waller, Dr. A. D.—Anæsthetics	25
Starling, Prof. E. H.—Tissue Metabolism	25
Sherrington, Prof. C. S.—Mental and Muscular Fatigue	20
Starling, Prof. E. H.—Dissociation of Oxy-hæmoglobin	15
Section K.—Botany.	
Scott, Dr. D. H.—Structure of Fossil Plants	10
Darwin, Dr. F.—Experimental Study of Heredity......	30
Blackman, Dr. F. F.—Symbiosis between Turbellarian Worms and Algæ	5
Johnson, Prof. T.—Survey of Clare Island	30
Section L.—Education.	
Magnus, Sir P.—Studies suitable for Elementary Schools	5
Corresponding Societies Committee.	
Whitaker, W.—For Preparation of Report	20
Total	1249

SECTION G.

ENGINEERING.

OPENING ADDRESS BY SIR W. H. WHITE, K.C.B., Sc.D., LL.D., F.R.S., PRESIDENT OF THE SECTION.

ON the present occasion, when the meetings of the British Association for the Advancement of Science are held in the heart of this great Dominion, it is natural that the proceedings of Section G (Engineering) should be largely concerned with the consideration of great engineering enterprises by means of which the resources of Canada have been and are being developed and the needs of its rapidly increasing population met. It will not be inappropriate, therefore, if the Presidential Address is mainly devoted to an illustration of the close connection which exists between the work of civil engineers and the foundation as well as the development of British Colonies and Dominions beyond the seas.

British colonies and possessions have started from the sea-front and have gradually pushed inland. Apart from maritime enterprise, therefore, and the possession of shipping, the British Empire could never have been created. An old English toast, once familiar, but which has of late years unfortunately fallen into comparative desuetude, wished success to "Ships, Colonies and Commerce." A great truth lies behind the phrase: these three interests are interdependent, and their prosperity means much for both the Mother Country and its offspring. As colonies have been multiplied, their resources developed, and their populations increased, over-sea commerce between them and the Mother Country has been enlarged; greater demands have been made upon shipping for the over-sea transport of passengers, produce and manufactures; there has been a growing necessity for free and uninterrupted communication between widely scattered portions of the Empire, the maintenance of which has depended primarily and still depends on the possession of a supreme war-fleet, under the protection of which peaceful operations of the mercantile marine can proceed in safety, unchecked by foreign interference, but ever ready to meet foreign competition.

Now that our colonies have become the homes of new nations it is as true as ever that the maintenance of British supremacy at sea in both the mercantile marine and the war-fleet is essential to the continued existence and prosperity of the Empire. The trackless ocean supplies the cheapest and most convenient means of transport and intercommunication; continuous improvements in shipbuilding and marine engineering have abridged distances and given to sea-passages a regularity and certainty formerly unknown. It is a literal fact that in the British Empire the "seas but join the nations they divide." Every triumph of engineering draws closer the links which bind together its several parts. Greater facilities for frequent and rapid interchange of information of what is happening in all sections of the Empire and of knowing each other better should lead, and have led, to increased sympathy and a fuller realisation of common interest in all that affects the well-being of the Empire. Within the last few years the events of the Boer War have given remarkable proofs of the practical interest of the colonies in Imperial concerns and their readiness to share its burdens. The present year will always be remembered as that in which generous offers of assistance from the colonies in the task of strengthening the Royal Navy at a critical period have led to a conference the labours of which should produce important practical results and make our future secure. Organised cooperation between the Mother Country and the Dominions beyond the seas in the maintenance of an Imperial Navy adequate for the protection of vital interests is essential to that security; and, at last, there is a prospect that this end will be attained.

While claiming for the shipbuilder and marine engineer an important place in the creation and maintenance of the Empire, it is recognised that the work of other branches of civil engineering has been equally important. The profession of the civil engineer was described in the Charter granted to the parent institution in 1828 as "the art of directing the Great Sources of Power in Nature for the use and convenience of man; as the means of production and of traffic in States both for internal and external trade, as applied in the construction of roads, bridges, aqueducts, canals, river navigation and docks, for internal intercourse and exchange; and in the construction of ports, harbours, moles, breakwaters and lighthouses; and in the art of navigation by artificial power for the purposes of commerce; and in the construction and adaptation of machinery and in the drainage of cities and towns." Since this description was penned there have been great and unforeseen developments in many directions, including those relating to improvements in the use of steam, the generation and practical applications of electrical power, the manufacture and extended employment of steel. The main ideas expressed eighty years ago, however, still remain applicable to the beneficent work of the civil engineer. His skill and enterprise, backed by adequate financial provision, are continuously being applied to improve and extend means of production, internal and external means of communication, inland and over-sea navigation, the use of mechanical power and appliances, the acceleration and cheapening of transport, the development and utilisation of natural resources, and the direction of the sources of power in nature for the use and convenience of man. One of the chief fields of engineering operations at the present time is to be found in the Dominion of Canada, the governing authorities of which have appreciated the fact that bold enterprise and generous financial provision for the execution of great engineering works are essential to the progress and prosperity of the country. Its vast extent, its magnificent lakes and rivers, its agricultural and mineral riches, its forests, its unrivalled water-power, and many other potential sources of future wealth and progress, furnish exceptional incentives and opportunities to the engineer. From an early period in the history of Canada this fact has been realised, and attempts have been made to utilise natural advantages; while the same policy has been energetically adopted since the Dominion was established forty-two years ago. It is impossible in this Address even to enumerate the great engineering works which have been accomplished or are in process of execution; and it might be thought impertinent if the attempt were made by one who has only an outside knowledge of the facts. On the other hand, it may be of interest to illustrate by means of Canadian examples the truth of the general statement that civil engineering has exercised and must continue to exercise great influence upon the well-being and development of the British Empire.

By the kindness of the High Commissioner of Canada, Lord Strathcona—who has himself done so much for the development of the Dominion, including a great part in the construction of the Canadian Pacific Railway—the writer has been favoured with official reports and statistics bearing on the subject. These have been freely used in the statement which follows.

The subject is so extensive and the time available for this Address so short that it will be necessary to omit detailed reference to important applications of engineering which are necessarily made, under modern conditions, in all great centres of population. Amongst these may be mentioned building construction, sanitation, water supply, heating, lighting, telegraphy, telephony, tramways, electric generating stations and their plant, and gas manufacture. No attempt will be made to deal with the important assistance given by engineers to the operations of agriculture, mining and manufacture, or to the utilisation of the splendid forests of the Dominion, although the demands for machinery and mechanical power are in these respects exceptionally great, owing to the sparseness of the population and the magnitude of the work to be done. Notwithstanding the large immigration and rapid increase of population, these demands will certainly continue and will probably become greater as the area under cultivation is increased, as manufactures are developed, and the natural resources of the country more largely utilised. The example of the United States places this anticipation beyond doubt, and demonstrates the great part which the engineer must continue to play in the development of Canada.

Even when the limitations described have been imposed upon the scope of this Address, the field to be traversed is a wide one; and without further preface an endeavour will be made to describe a few of the most important services which the engineer has already rendered to the Dominion and will render in the immediate future.

Railways.

It has well been said that the great problem of to-day in Canada is that of providing ample and cheap transport for her agricultural, mineral, and forest products from the interior to the sea, and so to the markets of the world. Important as inland navigation may be as an aid to this enterprise, it cannot possibly compare with railway development in actual and potential results. Apart from that development the one united Dominion must have remained a dream; thanks to the rapid and efficient intercommunication furnished by railways, widely scattered provinces are knit together in friendly and helpful union, literally by "bonds of steel" which stretch from the Atlantic to the Pacific, and reach farther and farther north each year. Regions which would otherwise have remained inaccessible and unproductive have been turned into new provinces, the fertility and future development of which it is not easy to forecast, and practically impossible to exaggerate.

In this department successive administrations (both Federal and provincial) have realised the facts and possibilities of the position, and have given substantial assistance to private enterprise in the execution of great engineering works. Progress in railway development has been remarkable since Federation was accomplished forty-two years ago. During the preceding thirty years the total railway mileage in operation had been raised to 2278 miles; in 1887 it was 12,184 miles; in 1897, 16,550 miles; in 1907, 22,452 miles. The number of miles of railway actually under construction in 1907 was officially estimated at 3000, exclusive of lines projected but not yet under contract. In 1906, when the lines in operation were 21,353 miles, it was estimated by competent authorities that the railways under construction, and projects for extensions likely to be carried into effect in the immediate future, reached a total of at least 10,000 miles, while probable further extensions of about 3500 miles were under consideration. Further, it was estimated that the capital expenditure required to complete these schemes would be about 60 millions sterling. These figures may need amendment, but there are others representing ascertained facts which equally well illustrate the magnitude of the railway interests of the Dominion.[1] The total capital invested in Canadian railways in 1907 was officially reported to be about 234,390,000*l.*; the aid given to railways up to that date by Dominion and Provincial Governments, and by municipalities, considerably exceeded 36,000,000*l.* sterling in money; the land grants from the Dominion Government approached 32 million acres, while the Provincial Governments of Quebec, British Columbia, New Brunswick, and Nova Scotia had granted about 20½ million acres. The Governments have also guaranteed the bonds of railway companies to the extent of many millions of dollars. The capitalisation per mile of railway lines owned by the Governments (amounting to 1890 miles) is reported as being 11,400*l.*; this is practically the same amount as that for Indian railways, that for the United States being 13,600*l.*, and for New South Wales and Victoria about 12,600*l.* For British railways the figure given is 54,700*l.* per mile. The freight carried by Canadian railways in 1907 amounted to nearly 63,900,000 tons (of 2000 lb.), which included about 14,000,000 tons of coal and coke, nearly 4,500,000 tons of ores and minerals, 10,250,000 tons of lumber and other forest products, nearly 7,900,000 tons of manufactures, and 2,309,000 tons of merchandise. In 1875, when 4800 miles of railway were in operation, the corresponding freight-tonnage was 5,670,000 tons; so that while the length of railway increased nearly 4·7 times, the tonnage increased nearly 11·3 times. During the same period passengers increased from 5,190,000 to 32,137,000. For twenty-eight railways making returns the average revenue per passenger per mile was 2·232 cents, and for the four principal railways was 2·07 cents. For freight fifty-nine railways showed an average rate of 2·328 cents per ton-mile, and for the five principal railways it was 0·702 cent per ton-mile. The average distance travelled by a passenger was 64 miles, the corresponding figure for the United States being 30·3 miles. The average distance a ton of freight was hauled was 183 miles, as against 132 miles for the United States. In Canada, as the official reporter remarks, there is a small amount of suburban railway traffic and a low density of population. The following table is taken from the official Canadian Railway Statistics for 1907:—

	For each mile of Railway: Population	For each mile of Railway: Square miles of Territory
United States	381	13·61
United Kingdom	1,821	5·29
France	1,590	8·46
New South Wales	686	146·09
New Zealand	358	43·42
Victoria	360	25·89
India	10,119	61·09
Canada	289	161·8

Canada has therefore the highest mileage measured against population, and the lowest against territory.

The earliest great railway system of Canada, the Grand Trunk, had its beginnings in 1845; in 1907 it was working about 3600 miles within the Dominion. In association with the Government it is now engaged on the construction of the Grand Trunk Pacific Line, which will cross the Continent wholly in Canadian territory, and have a length of 3600 miles, exclusive of branches.

The story of the Canadian Pacific Railway is well known, and need not be repeated; the influence which its existence and working have had upon the prosperity of the Dominion has been enormous and beneficial since its opening in 1885, and experience of its effect has led to the promotion of other Trans-Continental lines. In June, 1907, the total length in operation was nearly 9000 miles, and the company owned in addition great lines of steamships employed on Atlantic and Pacific services.

The Canadian Northern Railway system represents one of the most striking examples of recent railway development in the Dominion. In 1907 it was working nearly 2600 miles in the North-Western provinces, about 150 miles in Ontario, 500 miles in the Province of Quebec, and 430 miles in Nova Scotia and Cape Breton, making a total of nearly 3700 miles. In 1908 its mileage on the main system was reported to have increased to nearly 3400 miles, and the total length in operation had become 4800 miles. The North-Western Provinces have given substantial assistance to this great system, and its promoters are said to aim at a complete Trans-Continental route, as well as the development of railway communication to Hudson's Bay and the establishment of a line of steamships therefrom to Great Britain.

Besides these three great railway organisations, which in 1907 controlled about 75 per cent. of the mileage in operation, there are a large number of smaller companies, making up a total of about 80. Their total earnings in 1907 amounted to 29,350,000*l.*, the total working expenses being 20,750,000*l.* Earnings from freight service were (in round figures) 19,000,000*l.*; from passenger service, 7,837,000*l.*; from express services, 655,000*l.*; from mails, 325,000*l.*, the balance coming from miscellaneous items. The total number of persons employed by the railways was 124,000; their salaries and wages amounted to 11,750,000*l.* It was officially estimated that if to the railway employees were added persons employed in factories for rolling stock and railway materials, as well as those engaged in the casual service and shipping, with an allowance for their families, "quite 25 per cent. of the population win their daily bread from the carrying trade" of the Dominion.

The equipment of the Canadian railways in 1907 included 3504 locomotives, 3642 passenger cars, and 113,514 freight cars. In the opinion of the official reporter on railway statistics, based chiefly on a comparison of the proportion of rolling stock to mileage in Canada and the United States, a considerable increase of rolling stock is required, and there is a possibility of greater efficiency being obtained in the utilisation of existing freight cars. The manufacturing resources of the Dominion are declared to be fully capable of meeting all requirements, as in 1907 they produced 227 locomotives, 397 passenger cars, and 13,350

[1] Most of these statistics are taken from the valuable Report for 1907, presented to the Minister of Railways and Canals by Mr. Butler, Deputy Minister and Chief Engineer of the Department.

freight cars. A reduction of grades and curvatures has been carried out on the principal railways in recent years, and this has permitted the hauling of heavier loads. It is estimated that in 1907 the average earnings per ton of freight hauled were 1·472 dollars, and the average earnings per passenger carried were 1·219 dollars. The earnings per train mile were 1·953 dollars, and the working expenses 1·381 dollars. The total earnings per mile of railway were 6535·64 dollars, and the working expenses were 4620·9 dollars. The working expenses were divided as follows in the official report:—

	Per cent.
Maintenance of way and structures	20·13
,, ,, equipment	20·88
Conducting transportation	55·25
General expenses	3·74

Allowing two cords of wood fuel to be equal to one ton, 5,609,000 tons of fuel—of which 5,578,000 tons were coal—were consumed by Canadian railway locomotives in 1907 in running 100,155,000 miles. The total cost was about 3,027,500*l*., equal to 14·59 per cent. of the working expenses.

From this brief summary of facts some idea may be gained of the rapid development of Canadian railways, their immense capital value and traffic, and the remarkable influence they have had upon the progress and population of the Dominion. It is a matter for satisfaction that British capital and engineering skill have contributed in no small measure to produce this development, and it may be hoped that in the future they may render even greater service.

Inland Navigation.

The most important system of inland navigation which Canada possesses is primarily due to the existence of the Great Lakes and the St. Lawrence River; but the utilisation of these natural advantages and the construction of a continuous navigable channel from the sea to the head of Lake Superior is due to the work of engineers. The importance of such a navigable waterway leading to the heart of the Dominion was recognised long ago by the Government. The first canal is said to have been opened in 1821, and from that time onwards the canal system has been developed, but the greatest progress has been made during the last forty years under successive Administrations. Up to March 31, 1907, the capital expenditure on Canadian canals, exclusive of outlay by the Imperial Government, has approached 18,350,000*l*. sterling, of which more than ten millions have been spent on enlargements. Besides minor canal systems, many of which are important, a great "trunk system" of water-transit has been created from Montreal to Port Arthur, at the head of Lake Superior, this all-water route being nearly 1300 miles in length, having a minimum depth of water of 14 feet and effecting a total vertical rise of about 600 feet from tidal water in the St. Lawrence to Lake Superior. In order to effect this rise forty-nine locks are provided, most of which are 270 feet long and 45 feet wide, enabling vessels 255 feet long to be accommodated. Out of the total length of more than 1200 miles, only 73½ miles consist of artificial channels. The Welland Canal, connecting Lakes Erie and Ontario—with a total rise from lake to lake of 327 feet, effected in twenty-five locks—is 26¾ miles long. This canal dates from 1824; its enlargement to present dimensions was begun in 1872, and occupied fifteen years; the total expenditure on the canal has been nearly five and a half millions sterling. Another important section of the waterway is the Sault Ste. Marie Canal—about 6000 feet in length and from 142 to 150 feet wide between the pier-ends, with a lock 900 feet long, 60 feet wide, having 20¼ feet of water over the sills. The difference of level between Lakes Superior and Huron is 18 feet. Commenced in 1888, the Sault Ste. Marie Canal was opened for traffic in 1895, the cost being about 930,000*l*. Like its predecessor on the United States side of St. Mary's River—the so-called "Soo" Canal affords *free passage* for the ships of both countries. In 1898 about two and three-quarter millions represented the tonnage of vessels passing through the Canadian Canal, and of this total about 403,000 tons was in Canadian vessels. In 1907 the total tonnage had risen to 12,176,000 tons, of which 2,288,000 was in Canadian vessels. The Soulanges Canal is fourteen miles long, with a rise of 84 feet effected in four locks. Commenced in 1892, it was opened for traffic in 1899, and cost nearly 1,400,000*l*. The Lachine Canal was commenced in 1821, enlarged in 1843 and 1873, and, as completed in 1901, is 8½ miles long, has 45 feet rise, effected in five locks, and has cost from first to last about 2,300,000*l*.

In the construction of this great waterway many difficult engineering problems have been solved, and every modern improvement has been introduced; electricity has been utilised in its equipment, both for power and lighting, so that navigation can proceed by night as well as by day. For the years 1903–7 the canals were declared *free of tolls*; but it is estimated officially that if tolls on the ordinary scale had been collected the revenue for 1907 would have exceeded 91,000*l*. In these five years the water-borne traffic of the Dominion increased from 9,204,000 tons in 1903 to 20,544,000 tons in 1907; in the same period the increase in Canadian railway traffic was from 47,373,000 tons to 63,866,000 tons. The official reporter justly remarks that "these results are exceedingly encouraging."

It was recognised long ago that the utilisation of the waterways of Canada from the Great Lakes to the sea would yield considerable advantages by facilitating cheap transport of agricultural products of the fertile regions from the great North-West, but the Canadian portions of that territory were then regarded as "a great lone land." Subsequent developments of the corn-growing regions of Canada have emphasised the value of the water route and its great potentialities. In his "History of Merchant Shipping" (published 1876) Lindsay dwelt upon this point, and foresaw that if the waterways of Canada were made continuously navigable a struggle for supremacy in over-sea trade must arise between New York and the Canadian ports of Montreal and Quebec. This struggle is now in full force, so far as the grain trade is concerned, and it is likely to grow keener. The quantity of grain passed down the whole length of the St. Lawrence navigation to Montreal increased from about 450,000 tons in 1906 to 685,000 tons in 1907, while the quantity carried to Montreal by the Canadian Pacific Railway was about 387,000 tons for 1906 and 384,000 tons for 1907. On the other hand, the quantity carried by canals in the United States to New York fell from 294,500 tons in 1906 to 230,800 tons in 1907.

An important addition to the Canadian canal system has been proposed, and its execution will probably be undertaken when great works now in progress have been completed. This route extends from Georgian Bay on Lake Huron to the St. Lawrence, and would utilise Lake Nipissing as well as the French and Ottawa rivers. The distance to be traversed would be 450 miles, less than that of the present all-water route. On the basis of careful surveys it has been estimated that a canal having 20 feet depth of water could be constructed at a cost of twelve millions sterling, upon which capital a reasonable dividend could be paid, even if the charges made for transport were one-third less than the lowest rates of freight possible on United States routes to New York. It would, of course, be most advantageous to have the available depth of water increased from 14 to 20 feet, thus making possible the employment of larger and deeper draught vessels between the Lakes and Montreal. Considerable economies in the ratio of working expenses to freight earnings would be effected, break of bulk in transit to the sea would be avoided, and the cost of transport greatly reduced.

The magnitude of the grain trade and its growth may be illustrated by the following figures for recent years:—In 1897 the grain cargoes passed down the Welland Canal to the ports of Kingston and Prescott numbered 377, and represented 515,000 tons; for 1907 the corresponding figures were 518 cargoes, weighing 841,000 tons. As to the elevators and mechanical appliances for handling economically these huge quantities of grain, nothing can be said here, although they involve the solution of many difficult engineering problems and have been greatly simplified and improved as experience has been gained.

The bulk of the canal traffic, of course, moves eastwards and outwards from the interior provinces. For example, of the total quantity of freight (1,604,321 tons) passed through the whole length of the Welland Canal in 1907, about 75 per cent. moved eastwards, and more than 62 per cent. of the 2,100,000 tons which passed through the St. Lawrence canals moved in the same direction.

Shipping on the Great Lakes.

Canadian shipping and shipbuilding on the Lakes have made considerable progress in recent years, although they do not rival those of the United States. According to authoritative statements there were not twenty Canadian steamers engaged in the transport of grain fifteen years ago; only three of these were steel-built, and the largest carried only 90,000 bushels. The total carrying capacity of Canadian grain-carriers at the present time has been estimated at ten million bushels, and the capital invested in the fleet is said to be about three millions sterling. Between the harvest and the close of navigation in winter it is estimated that no fewer than sixty million bushels of grain can be moved from port to port in Canadian steamers.

Many special engineering features have been introduced into the structures and equipment of these Lake grain-carriers. They are really huge steel barges of full form, of uniform cross-section for a considerable portion of their length; and they possess enormous cargo capacity, moderate engine power and speed, with structures of a simple nature which can be largely standardised and made to resemble bridge-construction rather than ordinary ship-building. They can be built in a short time, the largest vessels occupying about four months in construction. In this way the cost of construction is cheapened, but the rates for labour and materials prevailing in the Lake ship-yards are so high relatively to British costs that at present these grain-carriers are said to cost about 40 per cent. more (per ton dead weight carried) than the cost of ordinary "tramp" steamers built in Great Britain. Their holds and hatchways are arranged so as to facilitate the rapid shipment and discharge of cargoes. At their ports of call special mechanical appliances are provided for dealing with cargoes, most of which consist of grain, ore, or coal.

In the design and construction of these cargo-handling appliances the mechanical engineer has displayed great ingenuity, and the results obtained in rate of shipment and discharge of cargoes of grain, ore, and coal are remarkable. Cases are on record where vessels carrying 7000 tons dead weight have been loaded in four hours and discharged in ten hours; more than 5000 tons of ore have been discharged in about four hours. The draught of water of the steamers must be kept within moderate limits and the breadths of the locks are moderate, so that increase in carrying power must be chiefly obtained by increase in length; consequently, as individual cargoes are increased, a greater number of lifting appliances can be brought to bear simultaneously, and the rate of loading or discharge can be maintained or accelerated.

The season of navigation extends over only seven or eight months in the year; consequently, "quick despatch" is essential to success. A large vessel of this class has the following approximate dimensions:—Length, about 600 feet; breadth, 58 to 60 feet; depth, 32 feet; draught of water, 19 to 19½ feet when carrying 10,000 to 11,000 tons of cargo; corresponding displacement, 16,000 tons. The engines of such a ship develop about 2000 horse-power, and drive her at eleven to twelve statute miles per hour in fair weather. The large size and moderate speed result in very economical conditions of working, and the freight rates are exceedingly low. From official returns it appears that for these dead-weight cargoes the freight per ton mile across the Lakes is from 0·04 to 0·05 of a penny per ton mile, the corresponding railway rate being about ten times that amount. The multiplication of this type of vessel on the great Lakes is a proof that it satisfactorily fulfils the conditions of service. Similar vessels would not be well adapted for ocean work, which demands greater structural strength, different proportions, and a more liberal equipment; but shipbuilders generally may benefit from a study of the Lake steamers.

The greater portion of the traffic on the Lakes passes through the "Soo" canals. The voyages are comparatively short, the average length of the trip being about 840 miles. Consequently, individual vessels make several passages during the season when navigation is open, and the total number of passages as well as the total aggregate tonnage of the ships reaches very high figures. In the season of 1907, for example, when the canals were open less than 240 days, 20,440 vessels (counting as a vessel each passage), with an aggregate registered tonnage exceeding 44 million tons, passed through the United States and Canadian canals at the Soo. The aggregate freight tonnage carried exceeded 58 million tons; the weight of coal approached 11½ million tons; the iron ore carried weighed 39,600,000 tons; and the grain transported amounted to 136 million bushels. The conditions of the Suez Canal are, of course, entirely different, as vessels passing through are engaged on long voyages, and individual ships make few passages in the year. On the other hand, Suez Canal traffic proceeds uninterruptedly throughout the year, while the Soo canals are closed during the winter months. Subject to these differences in working conditions, it may be of interest to state that in 1907 4267 vessels of 14,728,000 tons passed through the Suez Canal, and paid transit dues which amounted to 4,460,000*l.*; whereas the passage of the "Soo" canals was free.

The St. Lawrence Ship Channel.

Closely allied with the waterway from Montreal to Lake Superior is the improvement of the channel of the St. Lawrence from Montreal to Quebec and beyond towards the sea. From the Straits of Belleisle to Montreal the distance is 986 miles; from Quebec to Montreal it is 160 miles. Formerly the minimum depth of water between Quebec and Montreal prevented the passage of vessels drawing more than 10 to 12 feet during the greater part of the season of navigation. In 1826 the question of deepening the river channel was raised; in 1844 the work was begun, but was abandoned three years later; in 1851 it was resumed, and has since been continued. In 1869 the minimum depth of the channel at low water was increased to 20 feet, in 1882 it was 25 feet; in 1888 27½ feet for 108 miles from Montreal to a point within tidal influence. A channel having a minimum width of 450 feet, and 550 to 750 feet wide at the bends, with a minimum depth of 30 feet, was completed in 1906 from Montreal to tide water at Batiscan. Certain work remains to be done between this point and Quebec in order to complete the project adopted in 1889 and amended in 1906, but it is anticipated this will be finished in about four years. Below Quebec the channel is 1000 feet wide. When once dredged it is stated that the channel remains permanent. Accidents in the channel are few. The Superintending Engineer in his Report of July, 1908, indicates the magnitude of the work done by comparisons with the Suez and Panama Canals, the figures standing as follow:—

	Length Miles	Minimum depth Feet	Minimum breadth Feet	Estimated excavation Cubic yards
Suez Canal	100 ...	29½	100 (bottom)	—
Panama Canal	49 ...	41	200 (min.) 500 (max.)	80,000,000
St. Lawrence Channel.	220[1] ...	30	450 (min.) 1000 (max.)	70,000,000

In 1844 the largest vessels navigating the St. Lawrence to Montreal were of 500 tons; now the *Virginian* and *Victorian* of the Allan Line (12,000 tons), and the *Laurentic* and *Megantic* of the White Star Line (15,000 tons), proceed to that port, and have made the passage from Quebec in less than ten hours. Ordinarily, this passage occupies eleven to twelve hours, the return passage being made in nine to ten hours.

In the execution of these great works a specially designed dredging plant, including several types, has been employed, and works about seven months in the year; and the rock dredging and blasting in the section below Quebec has involved great difficulty. The total amount of rock to be removed amounted to 1,700,000 cubic yards, extending over nearly three miles, and the whole bottom was covered with huge boulders, some of which were 30 to 40 tons in weight. These great masses had to be lifted before blasting and dredging was done. During the fiscal

[1] Length of channel requiring improvement demands dredging and excavation over a length of about 70 miles.

year 1907–8 the expenditure on dredging plant and dredging was nearly 132,000*l.*, and 4,832,000 cubic yards of material were removed. At the close of that year 56 millions of cubic yards out of the estimated total of 70 millions had been dredged; the length completed to 30 feet minimum depth was 59 miles out of 70 miles. These facts indicate the advanced condition of the undertaking and the prospect of its completion at an early date.

In order to secure the safe and continuous navigation of this channel by night as well as by day, under all conditions of weather, during the season when the river is open every precaution and aid which engineering skill and invention can provide has been laid under contribution. A marine signal service with telephonic equipment has been provided; submarine bells have been established for use in foggy weather; a complete system of buoys and lighting has been installed; the channel is periodically examined and swept to ensure that there are no obstructions; the question of prolongation of the season for navigation by the use of ice-breakers is being studied. The harbour of Montreal has been greatly improved in accommodation and equipment, and the aggregate tonnage as well as average size of sea-going vessels using the port have been much increased. In 1898, 868 such vessels aggregating 1,584,000 tons arrived at Montreal; in 1907, 742 vessels aggregating 1,926,000 tons arrived. Of the latter, 522 vessels aggregating 1,525,000 tons were British. At the St. Charles Docks and Wharves, Quebec, in the season of 1907, 235 vessels of 1,009,000 tons were entered inwards, and 67 vessels of 249,000 tons outwards, the first outward steamer leaving on April 7, and the first ocean steamer arriving on April 26. The last arrival from the sea was on December 9, and the ice formed in the tidal basin on December 12.

Still further improvements of the St. Lawrence navigation are now proposed, and the work was commenced in 1907. It is intended to increase the depth of the channel to a minimum of 35 feet from the sea to Montreal, and the Superintending Engineer reported in 1908 that, with certain moderate additions to the dredging and steam plant, this work could be completed in six seasons. The widths and curves of the existing channel will not require any important changes, as they were designed from the first for the largest classes of steamships. When this increased depth has been obtained Montreal as a port will have an approach channel comparing favourably with that of other ports available for Transatlantic traffic. At Southampton the existing depth at low water in the approach channel is about 32 feet, and it is proposed to obtain 34 feet. At Liverpool the minimum depth at low water over the bar and in the approach channel in the Mersey is about 28 feet. The Ambrose Channel leading to New York is to have 40 feet depth at low water when the works are completed. Ample depth of water is of the first importance in the economical working of the largest and swiftest ships, and the Canadian Government has been well advised in deciding to carry out the great scheme above described.

Water-power.

Canada has unrivalled resources in water-power, and its extent and possible utilisation have been made the subject of investigation by engineers for many years past. One of the most important memoirs on the subject was presented to the Royal Society of Canada in his Presidential Address of 1899 by Mr. Keefer, C.M.G. In recent times many other engineers have studied the subject and carried out important works. Exact knowledge of the total power represented by the waterfalls and rapids of the Dominion is not available, nor can any close estimate be made of the power which may be employed hereafter in factories, mills, or industrial processes, because profitable employment obviously depends upon commercial considerations, which must be governed largely by the localities in which water-power may be found, and the cost of works and of transmission of energy to places where it can be utilised. It has been estimated that on the line from Lake Superior through the chain of lakes and rivers leading to Niagara and thence through the St. Lawrence to the sea eleven millions horse-power may be developed.[1] Mr. Langelier has estimated that in the Province of Quebec the water-power aggregates more than eighteen millions horse-power; other provinces all possess large resources of the same kind as yet untouched. The most striking example of the utilisation of water-power is that on the Niagara River, which I had the good fortune to visit in 1904, during my Presidency of the Institution of Civil Engineers; the works on the Canadian side were then in full progress, and at a stage which enabled one to realise completely their great difficulty and immense scale. The three companies the works of which are near the Falls on the Canadian side have provided for a total ultimate development of more than 400,000 horse-power, and a fourth establishment lower down the river, intended chiefly for the use of Hamilton, is to develop 40,000 horse-power. In the construction of the works, in the electric generating plant, the arrangements for transmitting power over long distances, and other features of importance remarkable engineering skill and daring have been displayed. American capital and enterprise have had much to do with these undertakings, as they have with many other important Canadian enterprises; but it may be hoped that British capital will keep its lead and be freely employed in the development and utilisation of all the resources of the Dominion, including that magnificent asset its water-power. The applications of water-power are already very numerous, including, not merely the creation of electrical energy and its use for lighting and power in towns and factories situated at considerable distances from the Falls, but for manufactures and industrial processes carried on near the Falls. Amongst these manufactures, that of aluminium and carbide of calcium may be mentioned, while paper- and pulp-mills and saw-mills constitute important industries. Great advances have been made in the transmission of electrical power over long distances, and very high pressures are being used. Electric traction on railways and tramways also derives its power from the same sources, and is being rapidly developed. In 1901 there were 553 miles of electric railways, and in 1907 815 miles.

[1] The *Times Financial Supplement*, April 2, 1906, contains a valuable article on this subject, from which many of the above figures are taken.

Over-sea Trade and Transport.

It was remarked at the outset that a great truth is embodied in the old toast of "Ships, Colonies, and Commerce," and the efficient and economical transport of passengers, produce, and manufactured goods between the Dominions beyond the Seas and the Mother Country is essential both for the development of Colonial resources and for the continued prosperity of the United Kingdom. The British mercantile marine commands the larger portion of the carrying trade of the world; its earnings constitute a valuable item in the national income; it forms one of the strongest bonds of union between the various parts of the Empire. This general statement may be illustrated by reference to the over-sea trade of Canada and to the shipping engaged therein.

The total value of the Imports and Exports of the Dominion in 1898 was close upon 61 millions sterling; in 1908 it exceeded 130 millions sterling, having more than doubled within ten years. During the year ending March 31, 1908, the vessels which were entered at Canadian ports (*inwards from the sea*) carrying cargoes were classified as follows in the official returns:—

	Ships	Tons register	Freight carried		Crews
			Tons weight	Tons measurement	
British ...	2,603	4,539,256	1,306,822	254,373	165,078
Canadian..	2,803	718,490	202,939	1,449,054	44,594
Foreign ...	2,878	1,758,549	887,154	36,618	86,293
Totals......	8,284	7,016,295	2,396,915	1,740,045	295,965

The corresponding figures for ships entered outwards for sea carrying cargoes were:—

	Ships	Tons register	Freight carried		Crews
			Tons weight	Tons measurement	
British ...	2,533	4,258,960	2,706,334	714,085	136,614
Canadian..	3,557	1,041,053	616,248	291,480	45,658
Foreign ...	4,132	2,211,605	1,454,787	538,499	88,093
Totals......	10,222	7,511,618	4,777,369	1,544,064	270,365

Taking the combined over-sea traffic inwards and outwards, it employed 18,506 ships of 14,528,000 tons, the cargoes of which aggregated 7,174,000 tons dead-weight and 3,284,000 measurement tons, the crews exceeding 576,000 officers and men.

Of the 2603 British ships entered inwards, there came from Great Britain 852 ships of 3,392,000 tons, carrying as cargoes more than 860,000 tons dead-weight and 153,600 tons measurement; while there came from British Colonies 399 ships of nearly 381,000 tons, carrying cargoes of 236,000 tons dead-weight and 44,000 tons measurement. Of the 2533 British ships entered outwards, there proceeded to Great Britain 732 ships of 2,529,000 tons, carrying cargoes of 1,635,000 tons dead-weight and 509,000 tons measurement; while there sailed for British Colonies 648 ships of nearly 400,000 tons, carrying cargoes of 259,000 tons dead-weight and 76,500 tons measurement.

It will be seen, therefore, that the British ships entered inwards carried more than 54 per cent. of the total dead-weight cargoes and 14½ per cent. of the measurement goods, while foreign ships carried about 37 per cent. of the dead-weight and rather more than 2 per cent. of the measurement goods. British ships entered outwards carried more than 56 per cent. of the total dead-weight, and more than 46 per cent. of the measurement; whereas foreign ships carried only about 30 per cent. of the dead-weight, and not quite 35 per cent. of the measurement.

The trade from and to ports in the British Empire amounted to 45 per cent. of the grand total dead-weight freight; and ships carrying the British flag—excluding Canadian vessels—carried about 56 per cent. of the grand total dead-weight, and nearly 30 per cent. of the measurement goods. Including Canadian vessels, the British Empire can claim possession of 67½ per cent. of the total dead-weight trade, and 82½ per cent. of the measurement goods. The average tonnage per ship for the British was about 1700 tons; for the Canadian vessels less than 300 tons; for the foreign ships a little more than 900 tons.

It may be interesting to add a few figures showing the magnitude of the *coasting trade* of the Dominion. In 1908 there arrived and departed 104,527 steamers aggregating nearly 42,857,000 tons, and 50,710 sailing ships aggregating 7,673,000 tons. The sailing ships included nearly 50,200 small schooners, sloops, barges, canal boats, &c., averaging about 150 tons each. The grand totals for the coasting trade were 155,237 ships of 50,530,000 tons, and of these 151,873 ships of 47,356,000 tons were classed as British in the official returns. It will be obvious that great importance must attach to every detail of the business involved in carrying on a shipping trade of the magnitude indicated by the foregoing figures, and still more is this the case in regard to the immensely greater transactions of British shipping considered as a whole. No pains must be spared in promoting economy or improving procedure, and even minute savings on particular items must be secured, since their aggregate effect may be of vast amount.

Since the introduction of iron for the structures of ships and of steam as the propelling power marvellous economies have been effected in the cost of over-sea transport. The chief causes contributing to this result have been (1) improvements in steam machinery, leading to great reductions in coal consumption; (2) considerable enlargement in the dimensions of ships; and (3) the supersession of iron by steel for structures and machinery. It is unnecessary, and would be impossible on this occasion, to deal in any detail with these matters, which have been illustrated repeatedly by many writers, including the speaker. On the other hand, it would be improper to leave altogether without illustration the remarkably low cost of sea transport under existing conditions, since it has great influence on the commerce of the British Empire and of the world.

Rates of freight, of course, vary greatly as the conditions of trade and the stress of competition change. At the present time these conditions remain unfavourable, although it may be hoped that there are signs of improvement, after long and severe depression. It will be preferable, therefore, to give facts for more normal circumstances, such as prevailed five or six years ago. Coal was then carried from the Tyne to London (315 miles) for 3*s*. 3*d*. a ton; to Genoa (2388 miles) for 5*s*. a ton; to Bombay (6358 miles) for 8*s*. 6*d*. a ton, including Suez Canal dues. The corresponding rates of freight were 0·111, 0·025, and 0·016 of a penny per ton-mile.

Grain was brought across the Atlantic for 9*d*. per quarter in large cargo steamers, whereas in former times, when it was carried in small vessels, the charge was 9*s*. 6*d*. Goods were carried 6400 miles eastward *viâ* the Suez Canal in tramp steamers at an inclusive charge of 25*s*. to 30*s*. a ton, the freight rate averaging about 0·05 of a penny per ton-mile. It was estimated at that time that the average railway rate per ton-mile in Great Britain for cost of transport and delivery of goods was about thirty times as great; but the moderate distances travelled, local and national taxation, high terminal charges, and the immense outlay involved in the construction, equipment, and maintenance of railways account for much of the great difference in cost of transport. The ocean furnishes a free highway for the commerce of the world.

Economy of fuel-consumption has played a great part in the reduction of working expenses in steamships. Fifty years ago from 4 to 5 lb. of coal per indicated horse-power represented good practice in marine engineering for screw steamships. At present, with quadruple expansion engines, high-steam pressures, and more efficient reciprocating engines from 1¼ to 1½ lb. is common practice, and better results are claimed in some cases. A cargo steamer of the tramp type, carrying 6500 tons dead-weight, can cover about 265 knots in twenty-four hours in fair weather for a coal consumption of 27 tons per day, representing an expenditure on fuel of 20*l*. to 25*l*. A larger vessel carrying about 12,000 tons dead-weight, driven by engines of similar type, would consume about 45 tons in covering the same distance at the same speed. This increased economy in fuel per ton-mile is the result of an increase in dimensions from 365 feet length, 47 feet breadth, and 24½ feet draught of water to a length of 470 feet, a breadth of 56 feet, and a draught of 27½ feet. The first cost of cargo steamers is small in relation to their carrying capacity and possible earnings, varying, of course, with the current demand for new steamships. In the present depressed condition of shipping, about 5*l*. 10*s*. per ton dead-weight is named as a current rate; in busy times the price may be 40 to 45 per cent. higher; even then it is small in proportion to earning power. Working expenses are kept down also by the use of efficient appliances for rapidly shipping or discharging cargoes, and so shortening the stay of ships in port. As an example a case may be mentioned when a ship of 12,000 tons dead-weight and 800,000 cubic feet measurement capacity had her full cargo discharged at an average rate of 300 tons an hour, a fresh cargo put on board at the rate of 250 tons an hour, and 1600 tons of coal shipped between 7 a.m. on Monday and noon on the following Friday—that is, in 101 hours. In another case a cargo weighing 11,000 tons was discharged in 66 hours. "Quick dispatch" in dealing with cargo is now universally recognised as essential, and it has been asserted that a saving of one day in discharging or loading a tramp steamer when she finds full employment may involve an expense equal to 1 per cent. on her first cost.

The "intermediate" type of steamer—in which large carrying capacity is combined with provision for a considerable number of passengers and moderate speed—is of comparatively recent date, but it has been developed rapidly and is subject to the universal laws to which all classes of shipping conform. Increase of size is adopted in order to favour economy in working and greater earning power, while increase in speed is made in some cases. Vessels like the *Adriatic* or *Baltic* of the White Star Line, the *Carmania* and *Caronia* of the Cunard Line, and the *George Washington* of the Hamburg-American Line illustrate this statement; while its latest and greatest examples are found in the two steamers now building for the White Star Line by Messrs. Harland and Wolff, which are said to be of 45,000 tons, to be intended to steam twenty to twenty-one knots, to provide accommodation for a great number of passengers, and to have large capacity for cargoes. In mail and passenger steamers of the highest speed increase in dimensions is devoted chiefly to provision for more powerful propelling apparatus and for a correspondingly large quantity of fuel, and the cargo-carrying capacity is relatively small; but the law of increase in size and cost is obeyed, and will be followed up to the limit which may be fixed by the vast outlay necessary in order to provide suitable harbours and dock accommodation with an adequate depth of water, or by commercial considerations and the possibility of securing a suitable return on the large capital expenditure. Growth in dimensions of ships will not be determined by the naval architect and marine engineer finding it impossible to go further, for there are even now in view possibilities of further progress if the shipowner so desires. Invention and improvement have not reached their ultimate limits.

The wonderful progress made during the last seventy years is well illustrated by the history of shipping trading between Canada and Great Britain, and it may be of interest to recall a few of the principal facts. For a long period trade and communications were carried on by wood-built sailing ships, many of the finest being Canadian built; but at a very early period Canadians had under consideration the use of steamships. One of the first steamers to cross the Atlantic was the *Royal William* paddle-steamer, built near Quebec in 1831. She was 160 feet long, 44 feet broad, of 363 tons burden, sailed from Quebec on August 5, 1833, and reached Gravesend on September 16, a passage of more than forty days, in the course of which sail-power was largely used. Cabot, in 1497, crossed in the good ship *Matthew*, of 200 tons burden, which was probably from 90 to 100 feet in length; so that three centuries of progress had not made very great changes in size of the ships employed. Wood was still the material of construction, and sails were still used as a motive power, although the steam-engine was installed. In 1839 it was a Canadian, Samuel Cunard, who secured—in association with two British shipowners, Burns and McIver—the contract for a monthly Transatlantic service from Liverpool to Halifax and Boston. The four steamers built were wood-hulled, driven by paddle-wheels, had good sail-power, and were of the following dimensions:—207 feet long, 34½ feet broad, 1150 tons burden, and about eight knots speed. A rapid passage to Boston then occupied about fourteen days.

Another Canadian enterprise, the Allan Line, started about fifty-six years ago. The first steamer built for the company was appropriately named the *Canadian*. At the time of her construction she ranked among the most important mercantile steamers in existence, and was quite up to date. Her dimensions were:—length, 278 feet; breadth, 34 feet; burden, 1873 tons. She had inverted direct-acting engines, driving a screw propeller, and a full sail equipment.

The Transatlantic service to New York, as was natural, rapidly surpassed that to Canadian ports, but the latter has been continuously improved, and its development has been marked by many notable events. For example, the Allan Line was amongst the first to use steel instead of iron for hulls, and in their two largest steamers now on service, dating from 1903, they were the first to adopt steam turbines for ocean-going ships, although their lead of the Cunard Company was not long. The *Virginian* and *Victorian* are 520 feet long, 60 feet broad, of 10,750 tons, and their maximum speed is 18 knots. The Canadian Pacific Railway authorities added shipowning to their great land enterprises at an early period in their career by building for the Pacific service in 1891 three important steamers, each 456 feet long, 51 feet broad, of 5950 tons, and 17 knots speed. These vessels continue on service, and have done splendid work as a link in the "all red" route. Since this step was taken the Canadian Pacific Railway has become possessed of a large fleet of Atlantic steamships, and quite recently has placed on the service from Liverpool to Quebec passenger steamships nearly 550 feet in length, 66 feet in breadth, of 14,200 tons, with a maximum speed of 20 knots.

The latest addition to the Canadian service has been made by the White Star Line in the form of two steamers, the *Laurentic* and *Megantic*, of 15,000 tons, 550 feet long, about 67 feet broad, and 17 knots speed. In the *Laurentic* an interesting experiment has been made—Messrs. Harland and Wolff having introduced a combination of reciprocating engines and a low-pressure turbine. This system was patented as long ago as 1894 by Mr. Charles Parsons, to whom the invention of the modern steam turbine and its application to marine propulsion are due. Mr. Parsons foresaw that while the turbine system would prove superior to reciprocating engines in ships of high speed and with a high rate of revolution, there would be a possibility of getting better results by combining reciprocating engines with low-pressure turbines in ships of comparatively slow speed, where a low rate of revolution for the screw-propellers was necessary to efficient propulsion. His main object, as set forth fifteen years ago, was "to increase the power obtainable by the expansion of the steam beyond the limits possible with reciprocating engines," and subsequent investigations led Mr. Parsons to the conclusion that it would be possible to secure an economy of 15 to 20 per cent. by using the combination system as compared with that obtainable with efficient types of reciprocating engines. Many alternative arrangements have been designed for combining reciprocating engines with low-pressure turbines; that now under trial associates twin-screw reciprocating engines, in which the expansion of the steam is carried down to a pressure of 9 to 10 lb. per square inch when working at maximum power, and then completed to the condenser pressure in a turbine. Triple screws are employed, the central screw—driven by the turbine—running at a higher rate of revolution than the side screws, which are driven by the reciprocating engines. The *Laurentic* has been but a short time on service, and few particulars are available of her performances as compared with those of her sister ship, fitted with reciprocating engines. It has, however, been reported that the results have proved so satisfactory that the combination system will probably be adopted in the two large White Star steamers of 45,000 tons now building at Belfast. This favourable view is fully confirmed by the performances of the *Otaki*, built by Messrs. Denny, of Dumbarton, for the New Zealand Shipping Company, and completed last year. That firm, as is well known, have taken a leading part in the application of the Parsons type of steam turbine to the propulsion of mercantile and passenger steamers, and they possess exceptional experience as well as special facilities for the analysis of the results of trials of steamships, having been the first private firm to establish an experimental tank for testing models of ships and propellers on the model of that designed by Mr. W. Froude and adopted by the Admiralty. Messrs. Denny have generously placed at the disposal of their fellow-shipbuilders the principal results obtained on the official trials and earliest voyages of the *Otaki*, and have compared them with similar results obtained in sister ships fitted with reciprocating engines.[1] The *Otaki* is the first completed ship fitted with the combination system and subjected to trial on service, and as the successful application of that system to cargo steamers and steamers of the intermediate type would result in a considerable economy in the cost of over-sea transport, it may be of interest to give some details of her recorded performance. She is 465 feet long, about 60 feet broad, and of 7420 tons (gross). Her dead-weight capability is about 9900 tons on a draught of 27 feet 6 inches, and the corresponding displacement (total weight) is 16,500 tons. The vessel was designed for a continuous sea-speed of 12 knots when fully laden, and the contract provided for a trial speed of 14 knots with 5000 tons of dead-weight on board. The trials were accordingly made at a displacement of about 11,700 tons. Her installation of boilers is identical with that of her sister ship, the reciprocating-engined twin-screw steamer *Orari*, which is 4 feet 6 inches shorter than the *Otaki*, but generally of the same form. On the measured mile the *Otaki* obtained a speed of 15 knots, while the *Orari* reached 14·6 knots. In order to drive the *Orari* at 15 knots about 12 per cent. more horse-power would have been required, and this is a practical measure of the superiority of the combination system over the reciprocating twin-screw arrangement in the *Orari*. The total water consumption per hour of the *Otaki* at 15 knots was 6 per cent. less than that of the *Orari* at 14·6 knots. If the *Otaki* also ran at 14·6 knots, the water consumption would have been 17 per cent. less than that of the *Orari* at the same speed. On the voyage from Liverpool to New Zealand the *Otaki* averaged about

[1] See a paper by Engineer Commander Wisnom, R.N., in the Proceedings of the Institution of Engineers and Shipbuilders in Scotland for 1909.

11 knots, which would have required on the measured mile only about 40 per cent. of the power developed when running 14·6 knots. With the ship laden more deeply, the average development of power on the voyage was about one-half the maximum developed on the measured mile, and this was disadvantageous to economy in the combination. Even in these unfavourable conditions the *Otaki* realised an economy in coal consumption of 8 per cent. on the voyage from Liverpool to New Zealand and back as compared with her reciprocating-engined sister ship; this represents a saving of about 500 tons of coal. Ordinarily the ship would leave England with sufficient coal on board for the outward passage, so that 250 tons less coal need be carried and a corresponding addition could be made to cargo and freight-earning. Probably as experience is gained the actual economy will prove greater than that realised on the maiden voyage; but even as matters stand there is a substantial gain, and a prospect of the extended application of the steam turbine to vessels of moderate and low speed. In view of results already obtained, the New Zealand Shipping Company have decided to apply the combination system to another vessel just ordered from Messrs. Denny.

In designing turbine machinery for vessels of moderate or low speed there must necessarily be conflicting claims. For maximum efficiency in steam turbines a high rate of revolution is necessary, whereas at moderate or low speeds it is antagonistic to propeller efficiency to run at this high rate of revolution. Engineers are at present much occupied with the study of arrangements by means of which these conflicting claims may be harmonised and greater total efficiency of propulsion obtained. Having regard to the enormous capital invested in cargo steamers of moderate speed, and the importance attaching to their economic working as influencing the cost of over-sea transport, it will be obvious that it is most desirable to find an arrangement in which the high speed of the rotor may be reduced by means of some form of gearing or its equivalent, so as to enable the screw shaft and its propeller to be run at a speed which will secure maximum propeller efficiency. Many proposals have been made, including mechanical gearing and hydraulic or electric apparatus, for transforming the rate of motion. Some of these are actually undergoing experimental trials, and are said to have given very promising results. One of the most important trials is that undertaken by the Parsons Marine Steam Turbine Company, which has purchased a typical tramp steamer, and is carrying out on her a series of trials in order first to ascertain accurately what are the actual conditions of steam and coal consumption with the present reciprocating engines, and then to ascertain the corresponding facts when those engines have been removed and a steam turbine with its associated gearing has been fitted. It is interesting to note in passing that in the earliest days of screw propulsion with slow-running engines it was found necessary to adopt gearing in order to increase the rate of revolution of the propellers, whereas at present interest is centred in the converse operation. Furthermore, if any system of gearing-down proves successful, it may be anticipated that its application will be extended to swift turbine-driven steamships, since it would enable good propulsive efficiency to be secured in association with rapidly running turbines of smaller size and less weight than have been employed hitherto.

The Marine Steam Turbine.

The rapid development of the marine steam turbine during the last seven years constitutes one of the romances of engineering, and the magnitude of the work done and the revolution initiated by Mr. Charles Parsons will be more justly appreciated hereafter than it can be at present. In some quarters there is a tendency to deal critically with details and to disregard broader views of the situation as it stands to-day. In May, 1909, there were 273 vessels built and under construction in which steam turbines of the Parsons type are employed, the total horse-power being more than three and a half millions. In the Royal Navy every new warship, from the torpedo-boat up to the largest battleships and armoured cruisers, is fitted with turbine engines; and the performances of vessels which have been tested on service have been completely satisfactory, in many instances surpassing all records for powers developed and speeds attained. In the war-fleets of the world this example is being imitated, although in some cases it was at first criticised or condemned. In the mercantile marine as a whole, while the new system has not made equal advance, many notable examples can be found of what can be accomplished by its adoption. It is now admitted that steam turbines enable higher speeds to be attained in vessels of given dimensions; and in steamers built for cross-channel and special services, where high speed is essential and coal consumption relatively unimportant, turbines have already ousted reciprocating engines. For over-sea service and long voyages an impression has existed that the coal consumption of turbine-engined ships would considerably exceed that of ships driven by triple or quadruple expansion reciprocating engines. Critics have dwelt on the reticence in regard to actual rates of coal consumption practised by owners of turbine steamships. Naturally there are other reasons for reticence than those which would arise if the coal consumption were excessive; but pioneers in the use of turbine machinery may reasonably claim the right of non-publication of results of trials in the making of which they have incurred large expenditure and taken considerable risks if they think that silence is beneficial to their business interests. Even if it were true that in the earliest applications of the new system economic results had not been obtained equal to those realised in reciprocating engines which have been gradually improved during half a century, that circumstance should not be regarded as a bar to acceptance of a type of engine that admittedly possesses very great advantages in other ways, but should be regarded as an incentive to improvements that would secure greater economy of coal. The evidence available, however, does not confirm the adverse view, and those familiar with the facts do not admit its truth. One example may be cited as it affects the Canadian service. In June, 1907, it was authoritatively stated that in the Allan liner *Virginian* the reports which had been circulated respecting the excessive coal consumption were unfounded, that the vessel was making passages at speeds of 17½ to 17¾ knots, as against the 17 knots estimated, and the rate of coal consumption was really about 1·4 lb. per indicated horse-power which would have been required to attain this speed if the vessel had been fitted with reciprocating engines. This result compares well with the consumption in ordinary passenger steamers running at high speeds in proportion to their dimensions, although in large cargo steamers and vessels of the intermediate type, working under much easier conditions and at very low speeds in proportion to dimensions, lower rates of consumption may be obtained. With these latter vessels the fair comparison is the combination system and not the pure turbine type which is adapted for high speeds.

The crowning triumph of the marine steam turbine up to the present time is to be found in the great Cunard steamships *Lusitania* and *Mauretania*. The passages made this year by the latter ship since she was refitted have been marvellously regular, and the 25 knots average across the Atlantic, which was the maximum contemplated in the agreement between the Government and the Cunard Company, has been continuously exceeded. As one intimately concerned with the design of the *Mauretania*, who has had large experience in ship design, has made a life-long study of the laws of steamship performance, and had the honour of serving on the committee which recommended the employment of turbines in these great ships, the writer ventures to assert that equal results could not possibly have been obtained with reciprocating engines in vessels of the same form and dimensions. Contrary opinions have been expressed, but they have been either based upon incorrect data or have omitted consideration of the fact that in vessels of such great engine-power it was necessary to have time to perfect the organisation of the staff in order to secure uniform conditions of stoking and steam production, and to bring the "human element" into a condition which would ensure the highest degree of efficiency in working the propelling apparatus. This necessity for time and training has been illustrated again and again in the case of new types of Transatlantic steamers, including some which held the record for speed prior to the appearance of the Cunarders. In the *Lusitania* and *Mauretania* the engine-power is fully 60 per cent. greater than that of their swiftest predecessors, yet no similar allowance appears to have been thought necessary by some critics, who assumed that performances on the earlier voyages represented the maximum capabilities of the vessels. Subsequent events have shown this view to be fallacious, and have justified the recommendation of the Turbine Committee and the action of the Cunard directors. Allegations made in regard to excessive coal consumption have also been disproved by experience, and in this respect the anticipations of the committee and of Mr. Parsons have been fully realised.

The marvellous regularity maintained by the *Mauretania* on a long sequence of consecutive Transatlantic passages —made under varying and in many cases very adverse conditions of wind, weather, and sea—illustrates once more, and on an unprecedented scale, the influence which large dimensions have upon the power of maintaining speed at sea. Starting from the eastward passage, beginning on February 3 last, and taking twelve passages (westward and eastward) which followed, the average speed for the thirteen passages, approaching 40,000 sea miles in length, has been 25½ knots; the lowest average speed in the series has been 25·2 knots, the highest average speed 25·88 knots. Many of the winter passages in this series were made in winter weather against strong winds and high seas, which would have considerably reduced the speed of her predecessors, but had small influence on the *Mauretania*. In many instances delays have been caused by fogs.

On seven consecutive passages made since the beginning of last May the average speed of the *Mauretania* in covering about 20,000 sea-miles has been 25·68 knots, the minimum speed for the passage having been 25·62 knots and the maximum 25·88 knots. On her contract trials the *Mauretania* maintained an average speed of 26·04 knots for a distance somewhat exceeding 1200 knots, the steaming time being rather less than forty-eight hours. On the passage when she averaged 25·88 knots, she ran 1215 knots from noon on June 17 to noon on June 19 (about forty-six hours), at an average speed of 26·23 knots, and by noon on June 20 had covered 1817 knots at an average speed of 26·18 knots for sixty-nine hours. The ship has, therefore, surpassed on service her performance on the contract trial.

In view of the foregoing facts and of others of a similar nature, it is reasonable to assume that as experience is enlarged and information is accumulated in regard to forms of propellers likely to prove most efficient in association with quick-running turbines, sensibly improved performances will be obtained. At present, in comparisons made between the efficiency of reciprocating-engined ships and turbine-engined ships, the former have the great advantage attaching to long use and extended experiment; but this is not a permanent advantage, and it may be expected that, good as the position is to which the marine steam turbine has attained in the brief period it has been in practical use, that position will be gradually improved. Whether or not other forms of propelling apparatus in their turn will surpass the steam turbine it would be unwise to predict. Internal-combustion engines are regarded in some quarters as dangerous and probably successful rivals to steam turbines in the near future. Within certain limits of size, internal-combustion engines no doubt answer admirably; but as dimensions and individual power of the engines are increased, the difficulties to be overcome also rapidly increase, and the fact is fully recognised by those having the best knowledge of those types of prime movers. On the whole, therefore, it seems probable that the turbine will not soon be displaced, whatever may happen eventually.

An Imperial Navy.

Three centuries ago a great English seamen and coloniser wrote these words:—

> "Whomsoever commands the sea commands the trade;
> Whomsoever commands the trade of the world commands the riches of the world, and consequently the world itself."

In these words Sir Walter Raleigh clearly expressed the doctrine of "sea-power," which in recent times has been emphasised by Admiral Mahan of the United States Navy and other writers. Twenty years ago when the movement began which has been followed by an unprecedented series of shipbuilding programmes, great additions to the *personnel* of the Royal Navy and large expenditure on improvements of existing naval bases and the creation of others at important strategical points, the same truth was expressed in a report made by three distinguished Admirals, one of whom, Admiral of the Fleet Sir Frederick Richards, subsequently became First Naval Lord of the Admiralty, and did much to give effect to the policy he had joined in recommending. One passage in this report may be quoted:—"No other nation has any such interest in the maintenance of an undoubted superiority at sea as has England, whose seaboard is her frontier." "England ranks amongst the great Powers of the world by virtue of the naval position she has acquired in the past, and which has never been seriously challenged since the close of the last great war. The defeat of her Navy means to her the loss of India and her Colonies, and of her place amongst the nations."

The "maintenance of an undoubted superiority at sea" in existing circumstances and in face of foreign competition is no easy task, and it is good to know that the Dominions beyond the Seas are ready to take a share of the heavy burden of Empire. In what way effect can best be given to this fundamental idea it is not easy to decide. It is necessarily a matter in which the views of all concerned must be considered, and a policy determined on which shall command hearty support from all portions of the Empire. It may be presumed that the arrangement of such a policy has been the chief object of this year's Defence Conference. The decision which may be reached and the action taken must exercise momentous influence upon the destiny of the Empire. Universal approval has been given to the arrangement for that Conference, and this is a happy augury of its ultimate success in framing a satisfactory scheme for the construction and maintenance of an Imperial Navy. Many valuable suggestions have been made by British and Colonial authorities as to the great lines on which such a scheme should be drawn, but this is not the place to enter upon a discussion of the subject. It may be permitted, however, as a sequence to the preceding remarks on over-sea transport, to remark that the protection of trade routes between the Mother Country and the Dominions beyond the Seas constitutes an essential duty; in the performance of which duty, especially in portions of trade routes adjacent to the Colonies, naval forces maintained by the Colonies may render valuable service. Such a policy in no way infringes the fundamental condition that supremacy at sea ultimately depends upon battle-fleets; while it recognises the fact, which past struggles have demonstrated, that behind and beyond the work of battle-fleets lies the need for adequate protection of commerce and communications. Moreover, it leaves Colonial Governments unfettered in making arrangements for the execution of that portion of the general scheme of defence which they may undertake; and there can be no inconvenience or loss from such independent action provided the scheme of Imperial defence has been considered as a whole, and an understanding reached in regard to the distribution of the work. At present the Mother Country alone possesses experience and means of manufacturing warships and armaments, so that gradual developments, requiring time and experience, will be necessary before the Colonies can become self-supporting in these respects should they desire to do so. On the side of *personnel* and its training also the Royal Navy must be the great school for all parts of the Empire. Finally, the full utilisation of Imperial defensive forces demands the existence of a complete understanding and the pre-arrangement of a common plan of campaign. In order to meet this essential condition there must be an Imperial staff.

The burden of naval defence has hitherto been borne almost entirely by the Mother Country. What the weight has been is hardly realised until the figures for expenditure are examined. As indications of what is involved in creating and maintaining a modern navy of the first class, it may be mentioned that in the ten financial years of the present century (including the current year 1909–10) the total expenditure on the Royal Navy amounts to 328 millions sterling. From 1885 to 1902, during the period the writer occupied the position of Director of Naval Construction and Assistant Controller of the Navy, the total outlay on the 245 ships for the designs of which he was responsible amounted to about 100 millions sterling. The stress of foreign competition and the growth in dimensions and cost of warships is leading to still greater expenditure on the Navy, and it is good to know that Canada, Australia, New Zealand, and South Africa are ready and willing to bear their share of the inevitable burden.

All branches of engineering have been and will be drawn upon freely in the execution of this great task. Mining and metallurgy assist by the production of materials of construction; mechanical and electrical engineers contribute machines and appliances required in shipyards and engine factories, as well as guns, gun-mountings, and mechanical apparatus of all kinds required in modern warships in order to supplement and economise manual power; marine engineers design and construct the propelling apparatus, and constantly endeavour to reduce the proportion of weight and space to power developed; naval architects design and build the ships; constructional engineers are occupied in the provision of docks, harbours, and bases adapted to the requirements of the fleet; and other branches of engineering play important, if less prominent, parts. The progress of invention and discovery is increasing, rapid changes occur unceasingly, the outlay is enormous, the task is never ending, but its performance is essential to the continued well-being of the Empire, and it must and will be performed.

NOTES.

The International Geodetic Association will meet in London on September 21 and following days at the rooms of the Institution of Civil Engineers, Great George Street, Westminster. The permanent commission of the association, consisting of one representative from each contributing country, is constituted as follows:—Belgium, Lieut.-Colonel Gillis; Chile, M. Bertrand; Denmark, Major-General Madsen; France, General Bassot (president); Germany, Prof. Foerster; Great Britain, Sir George Darwin (vice-president); Holland, Prof. H. G. van de Sande Bakhuyzen (perpetual secretary); Hungary, Prof. L. de Bodola von Zagon; Italy, Prof. Celoria; Japan, Dr. Hisashi Terao; Mexico, Sen. Angel Anguiano; Norway, Major-General Per Nissen; Portugal, General the Marquis d'Avila et de Bolama; Russia, General Artomonoff; Spain, Sen. Arrillaga; Sweden, Prof. Rosen; Switzerland, Prof. Gautier; United States, Mr. Tittmann. The Argentine Republic will be represented by Prof. Porro de Somenzi, Roumania by Colonel Rimniceano, India by Colonel Burrard, Egypt by Mr. Keeling, Australia by Mr. G. H. Knibbs. Among the seventy or eighty delegates, other than members of the permanent commission, are Prof. Helmert, chief of the Central Bureau, Potsdam, Prof. Albrecht and Prof. von Seeliger (Germany); Vice-Admiral Ritter v. Kalmar and Major-General von Sterneck (Austria), Lieut-Colonel Bourgeois and M. H. Poincaré (France), Baron Roland Eötvös (Hungary), Prof. Kapteyn (Holland), and Dr. Backlund (Russia). Among the representatives of Great Britain are the Astronomer Royal, Colonel Close, Major Leonard Darwin, Rear-Admiral Field, Sir Archibald Geikie, Sir David Gill, Dr. Glazebrook, Colonel Grant, Major Hills, Captain Lyons, and Colonel Sir William Morris. By command of the King, the delegates are invited to visit Windsor Castle on Saturday, September 25. On Monday, September 27, the meeting will be transferred to Cambridge, where the concluding sessions will be held.

The seventeenth annual exhibition of the Photographic Salon is now open at the Gallery of the Royal Society of Painters in Water Colours, 5A Pall Mall East. As the promoters of this exhibition are interested only in pictorial work, the technician expects to find among the works they have selected for presentation expressions of the most recent ideas as to approved methods, and the finest examples that these methods can furnish. Last year's Photographic Salon included a large number of colour photographs on autochrome plates, but this year there is not a single colour photograph of any kind. This must mean that, in spite of the improvements in the manufacture and in the methods of using plates for colour photography, the results obtained are not generally satisfactory from the artistic point of view. The shortcomings of these plates are well known and appreciated by those who have studied them, but they do offer possibilities of a certain measure of success in the rendering of colour, and we were not prepared for their total exclusion. The one hundred and thirteen pictures hung, selected, presumably, from many hundreds submitted, include examples of many styles and all degrees of merit. They range from a fuzziness that leaves the subject hardly recognisable to the keenest sharpness of definition, from the darkest to the lightest possible, and from those that have large flat patches of an even tint to those that show the most delicate and perfect modelling that can be desired. It is the possibilities of these great varieties of style that are of technical interest. The catalogue is defective in not giving the methods by which the various examples are produced, but we believe that we are correct in saying that the portraits by Mr. E. O. Hoppe are all unsophisticated platinum prints. These, and some of Mr. Frederick H. Evans's exhibits, and the portrait by Mr. Furley Lewis, will be specially instructive to those who print in platinum as showing the rich results obtainable by this method. In addition to the new work, there are nearly thirty examples of photographs by the late David Octavius Hill, made more than sixty years ago. These demonstrate that the vast strides photography has made during the last half-century have tended rather to increase the output and multiply diversity of method than to raise the quality of the work from a pictorial point of view.

By the death of Mr. Thomas Southwell, which took place at his residence in Norwich on September 5, science has lost an amateur naturalist of the very best type, and one who, by the extremely careful and painstaking nature of his work, set an example even to his professional brethren. Moreover, his natural-history studies were not undertaken for the purpose of filling up the time of an idle man, for during the best years of his life Mr. Southwell was in the employ of Gurney's (Barclay's) bank at Norwich, and could study his favourite subject only in the intervals of his professional work. In addition to possessing a great knowledge of the ornithology of his county, Mr. Southwell devoted special attention to whales and whaling, and for a long series of years his annual report in the *Zoologist* on the product of the season's whaling and sealing expedition afforded a mine of valuable information which could be obtained nowhere else. The great value of these reports consists in the fact that the information relating to the British portion of these industries was always at first hand, Mr. Southwell having got in touch with the whaling captains of Peterhead and Dundee. In addition to giving statistics concerning the annual catch of whales and seals, Mr. Southwell studied and collated all the information he could acquire concerning the distribution and migrations of the Greenland right-whale, and was thus enabled to formulate certain important theories on these points. In 1881 he published a small volume on the "Seals and Whales of the British Seas"; and his other writings include the third volume of Stevenson's "Birds of Norfolk," a revised second edition (1890) of Lubbock's "Fauna of Norfolk," Sir Thomas Browne's "Notes and Letters on the Natural History of Norfolk," a "Guide to Norwich Castle Museum," and a paper on the former breeding of the crane in East Anglia. At the time of his death Mr. Southwell was in his seventy-ninth year.

M. SANTOS-DUMONT has accomplished several successful flights with an aëroplane having a supporting surface of only nine square metres. On September 13 he travelled a cross-country distance of about five miles in five minutes upon this machine.

Science announces that the President of the United States has issued a proclamation setting aside the Oregon caves in the Siskiyou National Forest, in the State of Oregon, as a national monument. The area of the reservation is about 480 acres.

THE Paris correspondent of the *Times* announces that the fourth International Aëronautical Congress will be held at Nancy on September 18–23. Major Renard (France) will read a paper on the units of aëronautics and their nomenclature, and will submit a report on the results and lessons of the recent aviation week at Rheims.

MR. F. C. CONSTABLE, Wick Court, near Bristol, sends notes of observations of a remarkable pink glow observed in the direction of the sun between 6.40 p.m. and 6.58 p.m. on September 12. The pink colour seemed to be the same as that observed by him on a steamer journeying from Bombay to Karachi in 1883, a few days after the Krakatoa eruption.

PROF. SILVANUS P. THOMPSON, F.R.S., has consented to become the first president of the Illuminating Engineering Society, and influential support has been received from many distinguished authorities on matters of illumination in this country, on the Continent, and in America. The society will enter upon its opening session in November, and has every reason to hope for a long and prosperous existence. Anyone interested in the objects of the society and desiring to become a member should apply to Mr. L. Gaster, hon. secretary, 32 Victoria Street, London, S.W.

AT the autumn meeting of the Institute of Metals, which will be held at Manchester on October 14 and 15, it is expected that the following papers will be presented:—the constitution and properties of the ternary alloys aluminium-copper-tin, J. H. Andrew and C. A. Edwards; the surface appearance of solders, C. O. Bannister and H. J. Tabor; the technical assay of zinc, H. W. Greenwood; notes on the production of pure spelter, J. S. Glen Primrose; some causes of the corrosion of copper and brass, E. L. Rhead; the elastic breakdown of ductile materials, Prof. C. A. Smith; the copper-zinc alloys—a study of volume changes during solidification, Prof. T. Turner and M. T. Murray.

THE Reale Accademia dei Lincei makes the following announcements:—The royal prize for mathematics is divided equally between Profs. Enriques and Levi-Civita, and that for social and economic sciences is similarly divided between Prof. Rodolfo Benini and Dr. G. Mazzarella. From the Santoro foundation the academy has awarded a prize of 10,000 lire to Prof. Quirino Majorana, for his researches on wireless telephony, which have resulted in communication being established up to distances of 300–400 kilometres or more; in addition, minor awards to Prof. Gabbi, for researches on Malta fever, and Dr. Canovetti, to enable him to continue his experiments on air resistance. From the same benefaction grants have also been made to Profs. Vinassy de Regny and Gortani, for Alpine studies; Prof. Gorini, for investigating diseases of cheese; Prof. Silvestri, noxious insects; Prof. Almagià, study of precipices; the Lombardy commission for seiches on Laghi di Garda and Maggiore; Dr. Abetti, solar physics, in Prof. Hale's observatory. The Carpi prize for experimental physiology is divided between Drs. Baglioni and Lombroso. The late Prof. Sella has bequeathed to the academy a prize of 1000 lire, to be awarded annually to some assistant in an Italian physical laboratory, this being the second gift that the academy has received during the year.

THE seventh annual meeting of the South African Association for the Advancement of Science will be held in Bloemfontein on September 27 to October 2 inclusive, under the presidency of Sir Hamilton Goold-Adams, G.C.M.G. The business of the meeting will be held in three sections as follows:—Section I., astronomy, mathematics, physics, meteorology, geodesy, surveying, engineering, architecture, and geography: president, Prof. W. A. Douglas Rudge, Bloemfontein; Section II., chemistry, bacteriology, geology, botany, mineralogy, zoology, agriculture, forestry, sanitary science: president, Dr. C. F. Juritz, Cape Town; Section III., anthropology, ethnology, education, history, mental science, philology, political economy, sociology, and statistics: president, Mr. Hugh Gunn, Bloemfontein. The second award of the South Africa medal and grant will be made to Dr. Harry Bolus at this meeting. The South African Ornithologists' Union will meet in Bloemfontein at the same time and in the same buildings as the association. A series of lectures, under the auspices of the association, on Darwinism and human life, by Prof. J. Arthur Thomson, is being delivered in South Africa by way of celebrating the Darwin centenary. The honorary general secretaries of the meeting are Dr. J. D. F. Gilchrist, South African College, Cape Town, and Mr. R. T. A. Innes, Government Observatory, Johannesburg.

A LARGE portion of the August number of the *Museums Journal* is taken up by the report of the meeting of the Museums Association held at Maidstone in July. The programme of the meeting included a visit to Ightham to inspect the collection of flint implements brought together by Mr. B. Harrison.

IN the September number of Witherby's *British Birds* Mr. P. H. Barr appears to have disposed effectually of the remarkable idea that the black-headed gull acquires the feature to which it owes its name by means of a mysterious colour-change in the feathers of the head. He has proved that a moult takes place early in the year, usually in February, which embraces, not only the head, but the breast and back, and that at the conclusion of the process, which takes about a week, the black skull-cap is acquired. Occasionally young birds assume the black cap of the breeding plumage while they are still in the immature dress elsewhere.

ACCORDING to Bulletin No. 33 of the Biological Survey of the U.S. Department of Agriculture, which is devoted to the brown rat in the States, serious efforts are being made in North America and Japan to reduce the numbers of this rodent, which is regarded as the worst mammalian pest in the world. So far, however, the campaign has not been crowned with success, the annual destruction of from several hundred thousand to a million head in Japan making no appreciable diminution in its numbers. In the paper before us Mr. D. E. Lantz has given a very full account of the morphology, distribution, migration, and ethology of the rat, with suggestions as to the best means of hunting and trapping, and the elimination of conditions conducive to its rapid increase.

THE Belfast Naturalists' Field Club, the oldest club of the kind in Ireland, has always possessed a strong geological section. An interesting excursion was recently undertaken to the eskers at Drumfane and near Broughshane. The accompanying illustration shows the fine sections that occur in these glacial ridges in co. Antrim. We learn from a report in the *Northern Whig* for August 24 that determinations were made of the source of the material, which proved to be mainly derived from local rocks. The Cainozoic rhyolites of Cloughwater and Ballycloughan were visited later in the day. Rhyolitic lavas are not so limited in the British Isles as the report before us would suggest, since the enormous outpourings in the Snowdon area and in Borrowdale must be borne in mind; but those of Antrim have a thoroughly modern aspect, and may be compared with types in Hungary or in Mexico. Naturalists in the north of Ireland are fortunate in having established a tradition for good observational work, in which amateurs have played a most important part.

Gravel Pit, Drumfane, near Ballymena, County Antrim. Photographed by Mr. J. L. S. Jackson.

A NICE little question in nomenclature is raised by Dr. Ameghino in a paper published in the *An. Mus. Nat. de Buenos Aires*, vol. xix., pp. 107–209, under the title of "Le *Diprothomo platensis*, un précurseur de l'homme du Pliocène inférieur de Buénos Aires." It appears that in 1884 the author proposed the generic term Diprothomo for one of the hypothetical ancestors of *Homo sapiens*. Recently Dr. Ameghino obtained from a superficial stratum in Buenos Aires, regarded as of Lower Pliocene age, a calvarium of apparently low type, which in his opinion is generically distinct from Homo. For this supposed new genus he proposes to adopt the name Diprothomo with the new affix platensis. As having no tangible type, "Diprothomo" will probably be regarded as a *nomen nudum*, and if this be so many naturalists will be likely to say that it cannot be employed in a new sense. After restoring the skull to his own satisfaction, Dr. Ameghino concludes that it affords further evidence of his view as to the South American origin of the human race. Additional testimony in favour of this opinion is stated to be afforded by the lower jaw of a child with the angle inflected in marsupial fashion. The extinct South American genus Microbiotherium is regarded as the *fons et origo* of most mammals, and from this sprang Clenialites, the ancestor of the Primates.

THE *West Australian* newspaper of July 7 contains the report of an address, by Dr. J. B. Cleland, read before the West Australian Natural History Society at its annual meeting held at Perth. The subject was the Australian fauna and flora, and especially the effects produced on these by foreign invaders. After alluding to the rabbit-pest, the author stated that the inexcusable introduction of the fox for sporting purposes has led to its rapid multiplication in parts of Victoria, South Australia, &c., and the loss of many sheep. Cats have become wild, and near Perth, for instance, fierce and powerful in build, feeding on the native birds and smaller animals and rabbits where these are present. The Norway rat and the black rat seem not to have extended beyond man's more immediate surroundings. The dominant rat in Perth is the sociable black rat, the larger Norway rat being hitherto obtained only from the neighbourhood of the wharves at Fremantle and Perth. It is otherwise in Sydney, where both are found together in the town. These rats have brought with them several species of fleas, of which some will bite man when their original host is absent (*e.g.* has died). By this means plague, introduced by rats, is communicated to man. The sparrow, the starling, the goldfinch, the blackbird, and the Indian minah have all come to stay. Some of these eat much grain and fruit, while all tend to drive away and usurp the place of the beautiful, interesting, and useful native birds.

DR. E. JANCZEWSKI contributes to the *Bulletin international de l'Académie des Sciences de Cracovie* (No. 6) a short supplement to his monograph on the genus Ribes. In the same part Mr. C. Rouppert presents a revision of the discomycetous fungus Sphærosoma. This genus, of which a new species was discovered by the author, has been variously classed under the Pezizaceæ, Helvellaceæ, and Tuberaceæ. It is here referred to the Helvellaceæ, but is regarded as a connecting link with the other two families.

THE latest issue of the *Kew Bulletin* (No. 7) opens with a review of the known species of Impatiens from the Philippine Islands, communicated by Sir J. D. Hooker, which forms a continuation of the extensive survey of the genus, based on collections from India, China, and the Malayan region. Out of twenty-five species, collected chiefly in the neighbourhood of Luzon, only two agree with previously determined species. The author is of opinion that further exploration will lead to the discovery of many more species. In the same number there is published a decade of Diagnoses Africanæ (No. xxx.), which includes the type of a new liliaceous genus, Neodregea, allied to Dipidax.

It will add to the general estimation of the common cruciferous plant, the shepherd's purse, when it is realised that the species can be segregated into several elementary species or biotypes. The latest investigation, undertaken by Mr. G. H. Shull at the Station for Experimental Evolution of the Carnegie Institution of Washington, and described in Publication No. 112 of the institution, bears evidence with regard to the existence of at least four biotypes which breed true under ordinary conditions and can readily be crossed; they are distinguished by characteristic lobings of the leaf. The author has also investigated the type known as *Bursa* (*Capsella*) *Heegeri*, which bears round seed capsules; this plant was found in the market-place at Landau, Germany, but has been lost except under cultivation.

Black spots varying in size from 1/10-inch to 3/8-inch in diameter are occasionally noticed on chilled beef. Dr. Klein has investigated their nature, and finds them to be caused by the mycelium of a fungus, an oidium, which is quite harmless and does not alter the meat beyond their limits (Report to the Frozen Meat Trade Association).

An interesting contribution to the September number of *Travel and Exploration* is an account, by a writer calling himself "Pousse Caillou," of the region known as Changchenmo, the home of the Tibetan antelope (*Pantholops hodgsoni*) and the *Ovis ammon*, which lies north-east of Leh, on the Kashmir-Turkestan frontier. Here we find seventy or eighty miles of the most utterly forsaken country which can be imagined. The lower volcanic hills, broken into Gothic pinnacles, are backed by a coal-black precipice, featureless and rigid in outline, while the intervening valleys of pure sand are swept by bitterly cold winds. Game preservation is more rigidly enforced even than in Ladakh, only six licences for shooting being granted annually, and the bag of antelope is limited to six specimens. The writer vividly describes the difficulty of shooting this shy animal, the success of the stalk being often interfered with by the appearance of the kyang, half-wild horse or ass, which roams wild on these plateaux.

The report of the committee on ancient earthworks and fortified enclosures, prepared for presentation to the Congress of Archæological Societies for the current year, presents no features of startling novelty. Measures for protection of sites have been successful in the cases of Maiden Castle, Dorset; Thetford Castle Meadow and Hill, Norfolk; Stokeleigh Camp, on the Somerset side of the Avon; White Barrow, Wilts; the earthwork at Selsea; the old landmarks of Epping Forest; and Pendina's Camp, Cardiganshire. On the other hand, the committee has to report that in many cases the laying out of golf courses has caused the mutilation of ancient ramparts and ditches. The discovery of a portion of the Roman Wall of London on the site of Christ's Hospital; excavations at Caerwent and Caerleon, Caersws, in Montgomeryshire, and Elslack, near Skipton, in Yorkshire, were the most important operations of the year. The bibliography of current literature on the subject is a useful addition to the report of this committee.

It very rarely happens that three well-developed typhoons occur within the space of ten days; in the Bulletin of the Manila Weather Bureau for October, 1908, Señor Coronas gives an excellent discussion, with charts, of three such cyclonic storms which reached the central and northern parts of Luzon on October 4, 8, and 13, accompanied by photographs of the destruction caused. They all appear to have originated in the vicinity of the Western Caroline Islands, and to have travelled in a W.N.W. direction; on reaching the archipelago they were considerably modified in shape and extent, and crossed the China Sea in a somewhat more northerly direction. The rates of translation, during which the wind at times reached hurricane force, varied considerably, in one instance attaining the unusual speed of twenty-one miles an hour, but on reaching the China Sea the velocity of translation considerably diminished in all cases. The barometric fall was very rapid, the minimum at one station being 27·99 inches, although it was some fifteen miles from the vortex. Forewarned by valuable observations from Guam (Ladrone Islands) and Yap (Western Caroline Islands), the Manila Observatory was able to give timely notice in each case to its own stations and to foreign services.

Some interesting results are described and illustrated by Dr. A. S. King in No. 1, vol. xxx., of the *Astrophysical Journal*, where he publishes a paper on the Zeeman effect in the spectrum of titanium. The experiments were carried out at the Mount Wilson Observatory, field strengths of 12,500, 13,800, and 18,400 gausses being employed between the poles of a Du Bois electromagnet; the dispersion used was, generally, such that there were 0·93 Angströms per mm., the spectrograph being the 13 feet vertical Littrow. A table, containing nearly 300 lines, between λ 3904 and λ 6556, gives a summary of the results, and shows that the great majority of titanium lines are resolved into triplets. Notable among the exceptions are the lines at λ 4527·49 and λ 4544·86, each of which is resolved into seven components, and shows a regularity of structure identical in both; the line at λ 4281·53 has eight components. Two sextets and three quintuplets also show a certain regularity in their separations, which is not shown, however, by the lines having four components. Special attention was paid to the forty-four lines given in Lockyer's list of "enhanced" titanium lines, which do not appear to fall in any special class; thirty-five are triple, six are quadruple, one quintuple, and two sextuple. Two plates, which accompany the paper, beautifully illustrate some of the more interesting separations.

Attention is directed by Mr. G. N. Huntly, in a brief paper in the Journal of the Society of Chemical Industry, to a curious case of corrosion occurring in a stand-by boiler at the generating station of the London Electric Supply Corporation. The corrosion had been noticed two years previously, but attempts to check it by the addition of caustic soda to the boiler-water had proved unavailing. The interior of the boiler showed numerous blisters up to 30 mm. in diameter, most of them near the water-level; each blister contained a clear liquid with a black powder in suspension, and a pit was observed to be forming in the centre of each blister. Analysis showed the presence of ferrous sulphate and free sulphuric acid in the liquid contents, although the boiler fluid was alkaline and contained little sulphur. The action was traced to manganese sulphide in the steel, which had become oxidised with formation of sulphuric acid; as the water in the boiler was quiet, the acid remained trapped behind a film of rust, and acid corrosion could thus take place in an alkaline medium, the oxygen required to convert the sulphur into acid penetrating the blister more readily than the alkali of the water. Addition of sodium arsenite to the boiler-water in place of caustic soda completely stopped the trouble, perhaps by eliminating the dissolved oxygen. These experiments confirm the growing impression that the injurious effects of sulphur in steel cannot be wholly removed by the addition of manganese; so far from being harmless, the manganese sulphide appears to be a dangerous constituent, leading to fractures as well as to corrosion.

PROF. O. LEHMANN, of Carlsruhe, who is so well known for his work on liquid crystals, has done a great service to those wishing to repeat any of the beautiful experiments which can be performed with these bodies by giving, in the *Physikalische Zeitschrift* for August 15, detailed descriptions of thirty-two of the most convenient and suitable experiments to perform during a lecture on the subject.

THE *Physical Review* for July contains the second of a series of communications from Mr. G. W. Pierce, of the Jefferson Physical Laboratory of Harvard, on the behaviour of rectifiers of alternating electric currents such as are used as detectors of electric waves. In the present case electrolytic rectifiers have been studied by the aid of the Braun tube oscillograph, and the author finds that the theory of electrolytic polarisation is capable of explaining all the facts observed, if the slight polarisation capacity of the small platinum electrode of the rectifier is taken into account. The detector, when polarised by the superposition of a direct current, is almost perfect, that is, the current it produces is nearly all in one direction. It may therefore be compared with the crystal rectifiers dealt with in the author's first paper. The author proposes to examine the behaviour of vacuum-tube rectifiers before giving definite shape to any theory of crystal rectifiers.

THE *Century Magazine* for September contains two interesting engineering articles. The first of these deals with the great aqueduct now being constructed for bringing water from the Catskill Mountains to the City of New York. This aqueduct will be ninety-two miles long, and, to supply the 500,000,000 gallons required daily, more than 600 square miles of collection area must be utilised and several large reservoirs constructed. The article is well illustrated with photographs, sections, and maps. The second article is a first instalment giving an account of Fulton's invention of the steam-boat. While many engineers in this and other countries experimented towards the end of the eighteenth century, Fulton was the first to secure real success. However, it may comfort some of our British patriots to be reminded that the American vessel was fitted with one of Watt's engines, constructed in Birmingham and shipped to America. The article contains many original documents and drawings, and is of interest as showing that the modern troubles which many inventors have to face in working out their schemes and in overcoming red tape had their counterpart more than a century ago.

THE results of some experiments on solid steel bars under combined stress are given in an article in *Engineering* for August 20. The author, Mr. C. A. Smith, of the East London College, University of London, has already presented useful work in confirmation of Guest's law, and in this series has loaded solid specimens in compression and torsion, and also in tension and torsion. The necessity for doing this will be evident when it is remembered that Lord Kelvin suggested that, as a tension load lowers the torsional yield point, a compression load would raise it. Four different grades of steel were experimented on, of carbon content ranging from 0·09 per cent. to 0·48 per cent. Under combined compression and torsion, the maximum principal stress at yielding varied from 19,800 lb. to 36,500 lb. per square inch, while the maximum shear stress varied from 18,900 lb. to 20,400 lb. per square inch, the average variation from the mean of the latter stress being 2·16 per cent. Another series shows an average variation of the maximum shear stress from the mean of 1·87 per cent. only, this series including tests in tension, compression, torsion, and combined stress. Taking all the results given, the average variation from the mean of the maximum shear stress is about 2 per cent. The importance of these tests will be understood when the difficulties of testing solid specimens under combined stress are remembered, difficulties which seem to have been overcome successfully by use of the author's sphingometer, by means of which the tension and compression measurements are taken in three planes.

REFERRING to the letters published in NATURE of July 22 and 29 in regard to sonorous or musical sands, Prof. J. C. Branner, Stanford University, California, writes to direct attention to articles on this subject by Profs. H. C. Bolton and Alexis A. Julien, published in the Proceedings of the American Association for the Advancement of Science (vol. xxxii., pp. 251–2; vol. xxxiii., pp. 408–13; vol. xxxviii., pp. 137–40). We may remind Prof. Branner that the subject was discussed in NATURE by Prof. Bolton and Mr. Carus-Wilson twenty years ago (vols. xxxix.–xlvi.).

A NEW edition of Mr. P. H. L'Estrange's "Junior Course of Comparative Geography" has been published by Messrs. George Philip and Son, Ltd. Part v. of this book, too, has now been issued separately at the price of 10*d*. In the new edition all the maps of the original work have been reproduced in black and white, the names and symbols required for this course only being retained. The book has been revised throughout, and additional matter added, for example, on local geography.

OUR ASTRONOMICAL COLUMN.

HALLEY'S COMET RE-DISCOVERED.—To Prof. Max Wolf belongs the honour of re-discovering Halley's comet after an absence of more than seventy years. A telegram from the Kiel Centralstelle announces that the comet was discovered at the Königstuhl Observatory on September 11. Its position at 14h. 7·3m. (Königstuhl M.T.) was

R.A. = 6h. 18m. 12s., dec. = +17° 11′,

and its magnitude 16·0.

Mr. Crommelin's ephemeris position for September 11·9 was

R.A. = 6h. 18m. 4s., dec. +17° 16′,

so to the Greenwich calculators, Messrs. Cowell and Crommelin, must be given the credit of having prepared an ephemeris which agrees remarkably well with the observation. At present the comet is approaching the northern limit of Orion from the south-western region of Gemini, forming nearly a straight line with the stars γ Geminorum and 143 OΣ, the three objects being about equally spaced in the order γ—143 OΣ—comet. The following is an extract from Mr. Crommelin's ephemeris:—September 25·7, 6h. 18·5m., +17° 11′; October 9·1, 6h. 14·6m., +17° 8′; October 22·0, 6h. 4·9m., +17° 2′.

OBSERVATIONS OF MARS.—Some interesting observations of changes, during August, in the areas surrounding the southern ice-cap of Mars are reported by MM. Antoniadi, Quénisset, and Jarry-Desloges in the September number of the *Bulletin de la Société astronomique de France* (pp. 385–94). M. Antoniadi, observing at Juvisy on August 12, 14, and 16, found the planetary features so pale as to be almost unrecognisable. On August 15 the Orontes was suspected to be, and the Euphrates was certainly, double, whilst, later, the Amenthes was seen to be broad and diffuse. M. Antoniadi suggests that the pale greyness of the darker regions may be due to the interposition of very light clouds or of a mist in the Martian atmosphere. Both MM. Quénisset and Jarry-Desloges also direct attention to the unusual paleness of the dark regions of the planet during the past few weeks, and each account is illustrated by reproductions from the original drawings showing various aspects of the planet.

A LARGE GROUP OF SUN-SPOTS.—Despite the fact that we are now drawing near to a sun-spot minimum, the solar disc has, during the past fortnight, exhibited an extensive group of spots. An observation on August 28 showed a bright patch of faculæ some distance south of the equator on the eastern limb, and on the following day a small spot was observed near the limb to the north of this. Observations on September 6 showed that there was a group of small spots in about the latitude of the previously observed faculæ, and this developed until, on September 11, it was a diamond-shaped group, of medium-sized spots, of which the longest diagonal was about one-sixth the length of the sun's diameter; each of the four main spots was surrounded by a number of smaller nuclei.

THE TRANSVAAL OBSERVATORY.—From a note in the *Observatory* (No. 413, p. 369) we learn that the Transvaal Government, on behalf of the Government observatory, has accepted the gift of a photographic astronomical telescope from Mr. Franklin Adams. The triple-objective is of 10 inches aperture, and made by Messrs. Cooke and Sons. Two guiding telescopes, each of 6 inches diameter, accompany the main instrument. The telescope is erected, and is to be employed mainly in assisting Prof. Kapteyn, in his studies of the construction of the sidereal universe, by securing photographs of the southern heavens.

ARTIFICIAL IMITATION OF LUNAR LANDSCAPE.—By cooling the slag from an iron-ore, smelted in a furnace and run off at a temperature of about 1100° C., Mr. Paul Fuchs succeeded in obtaining a surface structure which appears to be a very good imitation, in miniature, of a typical lunar landscape. The cooling was done with water applied in various ways, and produced craters, mountains, and plains according to the conditions of the slag and of the cooling. Photographs of the results are reproduced on a plate accompanying No. 4348 of the *Astronomische Nachrichten*, wherein Mr. Fuchs describes his experiments.

TEMPERATURE AND PRESSURE CONDITIONS IN THE SOLAR ATMOSPHERE.—Two interesting letters dealing with the conditions obtaining in the solar atmospheres appear in No. 413 of the *Observatory* (September, pp. 359–63).

In the first, Mr. Buss returns to the question of the radial motions in sun-spots exhibited by Mr. Evershed's spectrograms, and shows how they may be interpreted to indicate that the visible umbral area of a spot is caused by the efflux of material from within rather than the influx of cooler matter from above. The facts that spots often endure for months, and that Mr. Evershed finds that the radial motions are confined to the "reversing layer," *i.e.* to the lower levels of the sun's general atmosphere, are quoted as supporting this view; the vortices are effects of the outrush. This idea of the spots being produced by effluence leads to the sequel that the vapours of the actual spot must be at a higher temperature, whereas the observations of Sir Norman Lockyer and others show the reverse. To overcome this difficulty Mr. Buss suggests that the spectrum observed is that of the vapours high above the visual umbral level, and that, could we but observe the unveiled spectrum of the umbra itself, we would find it to be a bright-line spectrum.

In the second letter Mr. Evershed continues the discussion with Prof. Whittaker regarding pressure in the "reversing layer." After quoting experimental evidence to show that pressure-shifts are apparently independent of the manner in which luminosity is produced, Mr. Evershed points to the fact that the spectrum of the "reversing layer" consists of bright lines, as demonstrating that there is no enormous pressure on the emitting vapours; otherwise one would expect a more continuous spectrum. Finally, he states that measures of spot spectra, made at Kodaikánal, do exhibit small, differential pressure-shifts; the most affected lines are slightly displaced, relatively, towards the violet, thus indicating a pressure in the umbræ of about one-third of an atmosphere less than in the surrounding regions. Further details of these results are to be published shortly.

PARALLAX OF THE DOUBLE STAR Σ 2398.—In No. 4348 of the *Astronomische Nachrichten* (p. 63), Dr. Karl Bohlin announces that the reduction of photographic observations, made at the Stockholm Observatory during 1907–8, shows that the parallax of the double star Σ 2398 is 0·484″. This star thus becomes the nearest known neighbour, in the northern sky, to the solar system, its distance being 426,000 astronomical units, or 6·7 light-years. A previous observation by Lamp, at Kiel in 1883–7, gave the parallax as 0·353″.

OUR FOOD FROM THE WATERS.[1]

AT the last meeting of the British Association in Canada (Toronto, 1897) I was able to lay before Section D a preliminary account of the results of running sea-water through four silk tow-nets of different degrees of fineness continuously day and night during the voyage from Liverpool to Quebec. During the eight days' traverse of the North Atlantic, the nets were emptied and the contents examined morning and evening, so that each such gathering was approximately a twelve-hours' catch, and each day and each night of the voyage was represented by four gatherings. This method of collecting samples of the surface fauna of the sea in any required quantity per day or hour from an ocean liner going at full speed was suggested to me by Sir John Murray of the *Challenger* Expedition, and was first practised, I believe, by Murray himself in crossing the Atlantic. I have since been able to make similar traverses of several of the great oceans, in addition to the North Atlantic, namely, twice across the equator and through the South Atlantic, between England and South Africa, and four times through the Mediterranean, the Red Sea, and the Indian Ocean to Ceylon; and no doubt other naturalists have done much the same. The method is simple, effective, and inexpensive; and the gatherings, if taken continuously, give a series of samples amounting to a section through the surface layer of the sea, a certain volume of water being pumped in continuously through the bottom of the ship, and strained through the fine silk nets, the mesh of which may be one two-hundredth of an inch across, before passing out into the sea again. In examining with a microscope such a series of gatherings across an ocean, two facts are brought prominently before the mind: (1) the constant presence of a certain amount of minute living things; (2) the very great variation in the quantity and in the nature of these organisms.

Such gatherings taken continuously from an ocean liner give, however, information only in regard to the surface fauna and flora of the sea, including many organisms of fundamental importance to man as the immediate or the ultimate food of fishes and whales and other useful animals.

It was therefore a great advance in planktology when Prof. Victor Hensen (1887) introduced his vertical, quantitative nets, which could be lowered down and drawn up through any required zones of the water. The highly original ideas and the ingenious methods of Hensen and his colleagues of the Kiel School of Planktology—whether all the conclusions which have been drawn from their results be accepted or not—have at the least inaugurated a new epoch in such oceanographic work, and have inspired a large number of disciples, critics, and workers in most civilised countries, with the result that the distribution of minute organisms in the oceans and the fresh waters of the globe is now much more fully known than was the case twenty, or even ten, years ago. But perhaps the dominant feeling on the part of those engaged in this work is that, notwithstanding all this activity in research and the mass of published literature which it has given rise to, much still remains to be done, and that the planktologist is still face to face with some of the most important unsolved problems of biology.

It is only possible in an address such as this to select a few points for demonstration and for criticism—the latter not with any intention of disparaging the stimulating work that has been done, but rather with the view of emphasising the difficulties, of deprecating premature conclusions, and of advocating more minute and more constant observations.

The fundamental ideas of Hensen were that the plankton, or assemblage of more or less minute drifting

[1] Evening discourse delivered before the British Association at Winnipeg on August 31 by Prof. W. A. Herdman, F.R.S.

organisms (both animals and plants) in the sea, is uniformly distributed over an area where the physical conditions are approximately the same, and that by taking a comparatively small number of samples it would be possible to calculate the quantity of plankton contained at the time of observation in a given sea area, and to trace the changes of this plankton both in space and time. This was a sufficiently grand conception, and it has been of great service to science by stimulating many workers to further research. In order to obtain answers to the problems before him, Hensen devised nets of the finest silk of about 6000 meshes in the square centimetre, to be hauled up from the bottom to the surface, and having their constants determined so that it is known what volume of water passes through the net under certain conditions, and yields a certain quantity of plankton.

Now if this constancy of distribution postulated by Hensen could be relied upon over considerable areas of the sea, far-reaching conclusions, having important bearings upon fisheries questions, might be arrived at; and such have, in fact, been put forward by the Kiel planktologists and their followers—such as the calculation by Hensen and Apstein that the North Sea in the spring of 1895 contained at least 157 billions of the eggs and larvæ of certain edible fish; and from this figure and the average numbers of eggs produced by the fish, their further computation of the total number of the mature fish population which produced the eggs—a grand conclusion, but one based upon only 158 samples, taken in the proportion of one square metre sampled for each 3,465,968 square metres of sea. Or, again, Hensen's estimation, from 120 samples, of the number of certain kinds of fish eggs in a part of the West Baltic, from which, by comparing with the number[1] of such eggs that would normally be produced by the fish captured in that area, he arrived at the conclusion that the fisherman catches about one-fourth of the total fish population—possibly a correct approximation, though differing considerably from estimates that have been made for the North Sea.

Such generalisations are most attractive, and if it can be established that they are based upon sufficiently trustworthy data, their practical utility to man in connection with sea-fishery legislation may be very great. But the comparatively small number of the samples, and the observed irregularity in the distribution of the plankton (containing, for example, the fish eggs) over wide areas, such as the North Sea, leave the impression that further observations are required before such conclusions can be accepted as established.

Of the criticisms that have appeared in Germany, in the United States and elsewhere, the two most fundamental are:—(1) that the samples are inadequate; and (2) that there is no such constancy and regularity in distribution as Hensen and some others have supposed. It has been shown by Kofoid, by Lohmann, and by others that there are imperfections in the methods which were not at first realised, and that in some circumstances anything from 50 to 98 per cent. of the more minute organisms of the plankton may escape capture by the finest silk quantitative nets. The mesh of the silk is 1/200th inch across, but many of the organisms are only 1/3000th inch in diameter, and so can readily escape.

Other methods have been devised to supplement the Hensen nets, such as the filtering of water pumped up through hose-pipes let down to known depths, and also the microscopic examination in the laboratory of the centrifuged contents of comparatively small samples of water obtained by means of closing water-bottles from various zones in the ocean. But even if deficiencies in the nets be thus made good by supplementary methods, and be allowed for in the calculations, there still remains the second and more fundamental source of error, namely, unequal distribution of the organisms in the water; and in regard to this a large amount of evidence has now been accumulated, since the time when Darwin, during the voyage of the *Beagle* on March 18, 1832, noticed off the coast of South America vast tracts of water discoloured by the minute floating alga *Trichodesmium erythraeum*, which is said to have given its name to the Red Sea, and which Captain Cook's sailors in the previous century called "sea-sawdust." Many other naturalists since have seen the same phenomenon, caused both by this and by other organisms. It must be of common occurrence, and is widespread in the oceans, and it will be admitted that a quantitative net hauled vertically through such a trichodesmium bank would give entirely different results from a haul taken, it might be, only a mile or two away, in water under, so far as can be determined, the same physical conditions, but free from Trichodesmium.

Nine nations bordering the north-west seas of Europe, some seven or eight years ago, engaged in a joint scheme of biological and hydrographical investigation, mainly in the North Sea, with the declared object of throwing light upon fundamental facts bearing on the economic problems of the fisheries. One important part of their programme was to test the quantity, distribution, and variation of the plankton by means of periodic observations undertaken four times in the year (February, May, August, and November) at certain fixed points in the sea. Many biologists considered that these periods were too few and the chosen stations too far apart to give trustworthy results. It is possible that even the original promoters of the scheme would now share that view, and the opinion has recently been published by the American planktologist, C. A. Kofoid—than whom no one is better entitled, from his own detailed and exact work, to express an authoritative verdict—that certain recent observations "can but reveal the futility of the plankton programme of the International Commission for the investigation of the sea. The quarterly examinations of this programme will, doubtless, yield some facts of value, but they are truly inadequate to give any trustworthy view of the amount and course of plankton production in the sea."[1] That is the latest pronouncement on the subject, made by a neighbour of yours to the south, who has probably devoted more time and care to detailed plankton studies than anyone else on this continent.

It is evident that before we can base far-reaching generalisations upon our plankton samples, a minute study of the distribution of life in both marine and fresh waters at very frequent intervals throughout the year should be undertaken. Kofoid has made such a minute study of the lakes and streams of Illinois, and similar intensive work is now being carried out at several localities in Europe.

Too little attention has been paid in the past to the distribution of many animals *in swarms*, some parts of the sea being crowded and neighbouring parts being destitute of such forms, and this not merely round coasts and in the narrow seas, but also in the open ocean. For example, some species of Copepoda and other small crustacea occur notably in dense crowds, and are not universally distributed. This is true also of some of the diatoms, and also of larger organisms. Many naturalists have remarked upon the banks of Trichodesmium, of Medusæ and Siphonophora, of Salpæ, of Pteropods, of Peridinians, and of other common constituents of the plankton. Cleve's classification into Tricho-Plankton (Arctic), Styli-Plankton (temperate), and Desmo-Plankton (tropical) depends upon the existence of such vast swarms of particular organisms in masses of water coming into the North Atlantic from different sources.

It is possible that in some parts of the ocean, far from land, the plankton may be distributed with the uniformity supposed by Hensen. It is important to recognise that at least three classes of locality exist in the sea in relation to distribution of plankton:—

(1) There are estuaries and coastal waters where there are usually strong tidal and other local currents, with rapid changes of conditions, and where the plankton is largely influenced by its proximity to land.

(2) There are considerable sea areas, such as the centre of the North Sea and the centre of the Irish Sea, where the plankton is removed from coastal conditions, but is influenced by various factors which cause great irregularity in its distribution. These are the localities[2] of the greatest economic importance to man, and to which attention should especially be directed.

(3) There are large oceanic areas in which there may

[1] It is probable that too high a figure was taken for this.

[1] "Internationale Revue der Hydrobiologie und Hydrographie," vol. i. p. 846. December, 1908.

[2] See Dakin, Trans. Biol. Soc. Liverpool, xxii, p. 544.

be uniformity of conditions, but it ought to be recognised that such regions are not those in which the plankton is of most importance to men. The great fisheries of the world, such as those of the North Sea, the cod fishery in Norway, and those on the Newfoundland Banks, are not in mid-ocean, but are in areas round the continents, where the plankton is irregular in its distribution.

As an example of a locality of the second type, showing seasonal, horizontal, and vertical differences in the distribution of the plankton, we may take the centre of the Irish Sea, off the south end of the Isle of Man. Here, as in other localities which have been investigated, the Phyto-Plankton is found to increase greatly about the time of the vernal equinox, so as to cause a maximum, largely composed of Diatoms, at a period ranging from the end of March to some time in May—this year to May 28, in the Irish Sea. Towards the end of this period the eggs of most of the edible fishes are hatching as larvæ.

This Diatom maximum is followed by an increase in the Copepoda (minute crustacea), which lasts for a considerable time during the early summer, and as the fish larvæ and the Copepoda increase there is a rapid falling off in Diatoms. Less marked maxima of both Diatoms and Copepoda may occur again about the time of the autumnal equinox. These two groups—the Diatoms and the Copepoda—are the most important economic constituents in the plankton. A few examples showing their importance to man may be given:—Man eats the oyster and the American clam, and these shell-fish feed upon Diatoms. Man feeds upon the cod, which in its turn may feed on the whiting, and that on the sprat, and the sprat on Copepoda, while the Copepoda feed upon Peridinians and Diatoms; or the cod may feed upon crabs, which in turn eat "worms," and these feed upon smaller forms which are nourished by the Diatoms. Or, again, man eats the mackerel, which may feed upon young herring, and these upon Copepoda, and the Copepoda again upon Diatoms. All such chains of food matters from the sea seem to bring one through the Copepoda to the Diatoms, which may be regarded as the ultimate "producers" of food in the ocean. Thus our living food from the waters of the globe may be said to be the Diatoms and other microscopic organisms as much as the fishes.

Two years ago, at the Leicester meeting of the British Association, I showed that if an intensive study of a small area be made, hauls being taken, not once a quarter or once a month, but at the rate of ten or twelve a day, abundant evidence will be obtained as to (1) variations in the distribution of the organisms, and (2) irregularities in the action of the nets. Great care is necessary in order to ensure that hauls intended for comparison are really comparable. Two years' additional work since in the same locality, off the south end of the Isle of Man, has only confirmed these results, viz. that the plankton is liable to be very unequally distributed over the depths, the localities, and the dates. One net may encounter a swarm of organisms which a neighbouring net escapes, and a sample taken on one day may be very different in quantity from a sample taken under the same conditions next day. If an observer were to take quarterly, or even monthly, samples of the plankton, he might obtain very different results according to the date of his visit. For example, on three successive weeks about the end of September he might find evidence for as many different far-reaching views as to the composition of the plankton in that part of the Irish Sea. Consequently, hauls taken many miles apart and repeated only at intervals of months can scarcely give any sure foundation for calculations as to the population of wide sea areas. It seems, from our present knowledge, that uniform hydrographic conditions do not determine a uniform distribution of plankton.

These conclusions need not lead us to be discouraged as to the ultimate success of scientific methods in solving world-wide plankton and fisheries problems, but they suggest that it might be wise to secure by detailed local work a firm foundation upon which to build, and to ascertain more accurately the representative value of our samples before we base conclusions upon them.

I do not doubt that in limited, circumscribed areas of water, in the case of organisms that reproduce with great rapidity, the plankton becomes more uniformly distributed, and a comparatively small number of samples may then be fairly representative of the whole. That is probably more or less the case with fresh-water lakes, and I have noticed it in Port Erin Bay in the case of Diatoms. In spring, and again in autumn, when suitable weather occurs, as it did two years ago at the end of September, the Diatoms may increase enormously, and in such circumstances they seem to be very evenly spread over all parts and to pervade the water to some depth; but that is emphatically *not* the case with the Copepoda and other constituents of the plankton, and it was not the case even with the Diatoms during the succeeding year.

I have published elsewhere an observation that showed very definite limitation of a large swarm of crab Zoëas, so that none were present in one net while in another adjacent haul they multiplied several times the bulk of the catch and introduced a new animal in enormous numbers. Had two expeditions taken samples that evening at what might well be considered as the same station, but a few hundred yards apart, they might have arrived at very different conclusions as to the constitution of the plankton in that part of the ocean.

It is possible to obtain a great deal of interesting information in regard to the "hylokinesis" of the sea without attempting a numerical accuracy which is not yet attainable. The details of measurement of catches and of computations of organisms become useless, and the exact figures are non-significant, if the hauls from which they are derived are not really comparable with one another and the samples obtained are not adequately representative of nature. If the stations are so far apart and the dates are so distant that the samples represent little more than themselves, if the observations are liable to be affected by any incidental factor which does not apply to the entire area, then the results may be so erroneous as to be useless, or worse than useless, since they may lead to deceptive conclusions. It is obvious that we must make an intensive study of small areas before we draw conclusions in regard to relatively large regions, such as the North Sea or the Atlantic Ocean. Our plankton methods are not yet accurate enough to permit of conclusions being drawn as to the number of any species in the sea.

The factors causing the seasonal and other variations in the plankton already pointed out may be grouped under three heads, as follows:—

(1) The sequence of the stages in the normal life-history of the different organisms.

(2) Irregularities introduced by the interactions of the different organisms.

(3) More or less periodic abnormalities in either time or abundance caused by the physical changes in the sea, which may be grouped together as "weather."

These are all obvious factors in the problem, and the constitution of the plankton from time to time throughout the year must be due to their interaction. The difficulty is to disengage them from one another, so as to determine the action of each separately.

Amongst the physical conditions coming under the third heading, the temperature of the sea is usually given a very prominent place. There is only time to allude here to one aspect of this matter.

It is often said that tropical and sub-tropical seas are relatively poor in plankton, while the colder Polar regions are rich. In fishing plankton continuously across the Atlantic it is easy from the collections alone to tell when the ship passes from the warmer Gulf Stream area into the colder Labrador current. This is the reverse of what we find on land, where luxuriant vegetation and abundance of animal life are characteristic of the tropics in contrast to the bare and comparatively lifeless condition of the Arctic regions. Brandt has made the ingenious suggestion that the explanation of this phenomenon is that the higher temperature in tropical seas favours the action of denitrifying bacteria, which therefore flourish to such an extent in tropical waters as seriously to diminish the supply of nitrogen food and so limit the production of plankton. Loeb,[1] on the other hand, has recently revived the view of Murray, that the low temperature in Arctic waters so

[1] "Darwin and Modern Science" (Cambridge, 1909), p. 247.

reduces the rate of all metabolic processes, and increases the length of life, that we have in the more abundant plankton of the colder waters several generations living on side by side, whereas in the tropics with more rapid metabolism they would have died and disappeared. The temperature of the sea-water, however, appears to have little or no effect in determining the great vernal maximum of Phyto-Plankton.

Considering the facts of photosynthesis, there is much to be said in favour of the view that the development, and possibly also the larger movements of the plankton, are influenced by the amount of sunlight, quite apart from any temperature effect.

Bullen[1] showed the correlation in 1903–7 between the mackerel catches in May and the amount of Copepod plankton in the same sea. The food of these Copepoda has been shown by Dakin to be largely Phyto-Plankton, and Allen has lately[2] correlated the average mackerel catch per boat in May with the hours of sunshine in the previous quarter of the year, thus establishing the following connection between the food of man and the weather :—Mackerel—Copepoda—Diatoms—Sunshine. One more example of the influence of light may be given. Kofoid has shown that the plankton of the Illinois River has certain twenty-nine-day pulses, which are apparently related to the lunar phases, the plankton maxima lagging about six days behind the times of full moon. The light from the sun is said to be 618,000 times as bright as that from the full moon; but the amount of solar energy derived from the moon is sufficient, we are told, appreciably to affect photosynthesis in the Phyto-Plankton. The effectiveness of the moon in this photosynthesis to that of the sun is said to be as two to nine, and if that is so Kofoid is probably justified in his contention that at the time of full moon the additional light available has a marked effect upon the development of the Phyto-Plankton.

As on land, so in the sea, all animals ultimately depend upon plants for their food. The plants are the producers and the animals the consumers in nature, and the pastures of the sea, as Sir John Murray pointed out long ago, are no less real and no less necessary than those of the land. Most of the fish which man uses as food spawn in the sea at such a time that the young fry are hatched when the spring Diatoms abound, and the Phyto-Plankton is followed in summer by the Zoo-Plankton (such as Copepoda), upon which the rather larger but still immature food fishes subsist. Consequently, the cause of the great vernal maximum of Diatoms is one of the most practical of world problems, and many investigators have dealt with it in recent years. Murray first suggested that the meadows of the sea, like the meadows of the land, start to grow in spring simply as a result of the longer days and the notable increase in sunlight. Brandt has put forward the view that the quantity of Phyto-Plankton in a given layer of surface water is in direct relation to the quantity of nutritive matters dissolved in that layer. Thus the actual quantity present of the substance—carbon, nitrogen, silica, or whatever it may be—that is first used up determines the quantity of the Phyto-Plankton. Nathansohn in a recent paper[3] contends that what Brandt supposes never really happens; that the Phyto-Plankton never exhausts any food constituent, and that it develops just such a rate of reproduction as will compensate for the destruction to which it is subjected. This destruction he holds is due to two causes: currents carrying the Diatoms to unfavourable zones or localities, and the animals of the plankton which feed on them. The quantity of Phyto-Plankton present in a sea will then depend upon the balancing of the two antagonistic processes—the reproduction of the Diatoms and their destruction. We still require to know their rate of reproduction and the amount of the destruction. It has been calculated that one of these minute forms, less than the head of a pin, dividing into two at its normal rate of five times in the day, would at the end of a month form a mass of living matter a million times as big as the sun. The destruction that keeps such a rate of reproduction in check must be equally astonishing. It is claimed that the *Valdivia* results, and observations made since, show that the most abundant plankton is where the surface water is mixed with deeper layers by rising currents. Nathansohn, while finding that the hour of the day has no effect on his results, considers that the development of the Phyto-Plankton corresponds closely with evidence of vertical circulation. Like some other workers, he emphasises the necessity of continuous intensive work in one locality: such work might well be carried on both at some point on your great lakes and also on your Atlantic coast. The *Challenger* and other great exploring expeditions forty years ago opened up problems of oceanography, but such work from vessels passing rapidly from place to place could not solve our present problems—the future lies with the naturalists at biological stations working continuously in the same locality the year round.

The problems are most complex, and may vary in different localities—for example, there seem to be two kinds of Diatom maxima found by Nathansohn in the Mediterranean, one of Chætoceros due to the afflux of water from the coast, and one of *Rhizosolenia calcaravis*, due to a vertical circulation bringing up deeper layers of water. As a local example of the importance of the Diatoms in the plankton to man, let me remind you that they form the main food of your very estimable American clam. The figures I now show, and some of the examples I am taking, are from the excellent work done on your own coasts in connection with fisheries and plankton by Prof. Edward Prince and Prof. Ramsay Wright and their fellow-workers at the Canadian biological station, on your eastern seaboard.

The same principles and series of facts could be illustrated from the inland waters. Your great lakes periodically show plankton maxima, which must be of vast importance in nourishing animals and eventually the fishes used by man. Your geologists have shown that Manitoba was in post-Glacial times occupied by the vast lake Agassiz, with an estimated area of 110,000 square miles; and while the sediments of the extinct lake form your celebrated wheat fields, supplying food to the nations, the shrunken remains of the water still yield, it is said, the greatest fresh-water fisheries in the world. See to it that nothing is done to reduce further this valuable source of food! Quoting from your neighbours to the south, we find that the Illinois fisheries yield at the rate of a pound a day throughout the year of cheap and desirable food to about 80,000 people—equivalent to one meal of fish a day for a quarter of a million people.

Your excellent "whitefish" alone has yielded, I see, in recent years more than 5,000,000 lb. in a year; and all scientific men who have considered fishery questions will note with approval that all your fishing operations are now carried on under regulations of the Dominion Government, and that fish hatcheries have been established on several of your great lakes, which will, along with the necessary restrictions, form, it may be hoped, an effective safeguard against depletion. Much still remains to be done, however, in the way of detailed investigation and scientific exploitation. The German institutes for pond-culture show what can be done by scientific methods to increase the supply of food-fishes from fresh waters. It has been shown in European seas that the mass of living food matters produced from the uncultivated water may equal that yielded by cultivated land. When aquiculture is as scientific as agriculture, your regulated and cultivated waters, both inland and marine, may prove to be more productive even than the great wheat lands of Manitoba.

Inland waters may be put to many uses: sometimes they are utilised as sewage outlets for great cities, sometimes they are converted into commercial highways, or they may become restricted because of the reclamation of fertile bottom lands. All these may be good and necessary developments, or any one of them may be obviously best in the circumstances; but, in promoting any such schemes, due regard should always be paid to the importance and promise of natural waters as a perpetual source of cheap and healthful food for the people of the country.

1 M. B. A. Journ., viii., 269. 2 *Ibid.*, vii., 394. 3 Monaco Bulletin, No. 140.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

A NUMBER of resolutions concerned with education were adopted last week at the Trade Union Congress held at Ipswich. Some called for the State maintenance of school children, for scientific physical education, and the development of the medical department of the Board of Education. Others demanded that secondary and technical education be an integral part of every child's education, and be secured by such a reform and extension of the scholarship system as would place a maintenance scholarship within the reach of every child, and thus make it possible for all children to be full-time day pupils up to the age of sixteen; and that the best intellectual and technical training be provided for the teachers of the children, that each educational district be required to train the number of pupil teachers demanded by local needs and to establish training colleges, preferably in connection with universities or university colleges. The interest in education thus manifested by the leaders of our working men may be regarded as a gratifying sign of the times. All who desire the welfare of the nation would welcome any real improvement in our system of educating suitably the men upon whom the success of our industries largely depends; but many competent persons will doubt the wisdom of the great extension of our scholarship system demanded by the Trade Union Congress. In any system of awarding scholarships every care must be taken to ensure that each scholarship holder has shown by his previous record that he is mentally qualified to benefit by the secondary and technical education which the scholarship makes possible, and will complete the course at the school. It is important to educate every person to the full extent of his capabilities, but it is folly to imagine that every boy or girl who is made to attend a technical school must of necessity be able to benefit from such attendance.

THE technical colleges throughout the country are now issuing their programmes of work for the coming session. We have received the educational announcements of the Northampton Polytechnic Institute, Clerkenwell, the syllabus of classes at the Sir John Cass Technical Institute, Aldgate, London, and the prospectus of the East Ham Technical College evening classes. The educational aim of the Northampton Institute is to provide classes in technological and trade subjects, attention being first paid to the immediate requirements of Clerkenwell, the district of London in which the institute stands. The day courses are for students willing to give the whole of their time for one, two, or more years to a systematic training in technology. Day courses are provided in mechanical engineering, electrical engineering, watch-making, and horological engineering. In horology, a very large amount of time is given to workshop practice. There are also day courses in technical optics, electrochemistry, and other subjects. Evening classes are held in a very great variety of subjects. At the Aldgate institution graded courses of study extending over several years are provided in the various departments, and also special lectures, with accompanying laboratory practice, are given to meet the needs of persons holding responsible positions in the manufacturing establishments in the neighbourhood who desire to keep in touch with modern developments in applied science. Among the announcements of such special work may be mentioned the course on liquid, gaseous, and solid fuel arranged for the benefit of workers in chemical and engineering establishments and others concerned with the use of fuel as a motive power; that on the fermentation industries, with particular attention to microbiology; and that concerned with metallurgical problems. The evening classes at East Ham are under the general supervision of a responsible principal, and it is consequently possible for a student to obtain advice in the direction of securing a properly coordinated course of study continuing from year to year. The numerous classes are adapted particularly to meet the requirements of young men and women engaged in the manual and other industrial trades of the locality.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 6.—M. Bouchard in the chair.—The theoretical tides of the geoïd, on the hypothesis of an absolute rigidity of the earth: Ch. **Lallemand**. Defining the geoïd as the surface of mean level confining a volume equal to that of the globe, the mean tides at the equator are worked out for both the solar and lunar waves.—The Brownian movement and molecular constants: Jean **Perrin** and M. **Dabrowski**. Experiments have been made on two emulsions of different substances containing minute particles in suspension. The results are applied to determine the constant N of Avogadro in Einstein's formula, and also in a formula based on the distribution of the particles under the action of gravity. The former leads to a value of 70×10^{22}, and the latter to $70{\cdot}5 \times 10^{22}$. The close accord of these results is a striking confirmation of the kinetic theory on which the formulæ are based. The most probable value of the charge of the electron e from these values is $4{\cdot}1 \times 10^{-10}$.—Calorimetric and cryoscopic constants of mercuric bromide: M. **Guinchant**. The measured latent heat of fusion gives a cryoscopic constant according to van 't Hoff's formula of 403; actual cryoscopic determinations in various solvents furnished a constant of 283 to 407, the average value being 340.—The life of fungi in fatty media: A. **Roussy**. For various moulds it was found that fatty substances were capable of replacing carbohydrates in culture media. The concentrations of fat most favourable for growth of the moulds were determined.—Some wild yams of Madagascar: Henri **Jumelle** and H. Perrier **de la Bathie**.—The experimental transmission of exanthematic typhus by the body louse: Charles **Nicolle**, C. **Comte**, and E. **Conseil**.—The geological structure of the peninsula of Cape Bon, Tunis: A. **Allemand-Martin**.

CONTENTS.