low temperature that the observed rapid movements within the solar envelope could not possibly take place. It scarcely needs demonstration to prove that extreme tenuity can alone account for the extraordinary velocities recorded by observers of solar phenomena. But *extreme tenuity* is incompatible with low temperature and the pressure produced by an atmospheric column probably exceeding 50,000 miles in height subjected to the sun's powerful attraction, diminished only one-fourth at the stated elevation. These facts warrant the conclusion that the high temperature established by our investigation is requisite to prevent undue density of the solar atmosphere.

It is not intended at present to discuss the necessity of tenuity with reference to the functions of the sun as a radiator; yet it will be proper to observe that on merely dynamical grounds the enormous density of the solar envelope which would result from low temperature, presents an unanswerable objection to the assumption of Pouillet, Vicaire, Sainte-Claire Deville, and other eminent *savants*, that the temperature of the solar surface does not reach 3000° C. J. ERICSSON

THE BRITISH ASSOCIATION

HOSTS and guests have been abundantly satisfied with the results of the Canadian Meeting of the British Association. The Canadians have done their very utmost for their guests, and the latter appear to have responded heartily. There have been, to judge from the very full reports in the *Times*, some notable incidents in connection with the meeting, which will no doubt be fully noticed in the reports from our Special Correspondents, which we hope to receive in time for next week's number.

The General Committee met on Wednesday, with Lord Rayleigh in the chair. The aggregate membership was reported as 1773, of whom 558 were old and 1215 new. The following are the grants of money that have been made:—

Mathematical Section.—Meteorological observations near Chepstow, 25*l.*; synoptic charts of the Indian Ocean, 50*l.*; reduction of tidal observations, 10*l.*; calculation of mathematical tables, 100*l.*; meteorological observations on Ben Nevis, 50*l.*; solar radiation, 20*l.*; meteoric dust, 70*l.*

Chemical Section.—Vapour pressures and refractive indices of salt solutions, 25*l.*; chemical nomenclature, 5*l.*; physical constants of solutions, 20*l.*

Geological Section.—Volcanic phenomena of Vesuvius, 25*l.*; Raygill fissure, 15*l.*; earthquake phenomena of Japan, 75*l.*; fossil Phyllopoda of the Palæozoic rocks, 25*l.*; fossil plants of British Tertiary and Secondary beds, 50*l.*; *Geological Record*, 50*l.*; erosion of sea-coasts, 10*l.*; circulation of underground waters, 10*l.*

Biological Section.—Table at Naples Zoological Station, 100*l.*; *Zoological Record*, 100*l.*; migration of birds, 30*l.*; exploring Kilimanjaro and adjoining mountains of Equatorial Africa, 25*l.*; recent Polyzoa, 10*l.*; marine biological station at Granton, 100*l.*; biological stations on coast of United Kingdom, 150*l.*

Geographical Section.—Exploring New Guinea, 200*l.*; exploring Mount Roraima, 100*l.*

Mechanical Section.—Patent legislation, 5*l.*

Anthropological Section.—Investigating the characteristic physical and other features of north-west tribes of Canada, 50*l.*; physical characteristics of the races in the British Isles, 10*l.* Total, 1525*l.*

In the case of the following Committees no money grants were voted:—Committees on practical standards for use in electrical measurements, for promoting tidal observations in Canada, for calculating tables of fundamental variations of algebraic forms, for securing harmonic analysis in reducing tidal observations, for comparing and reducing magnetic observations, for investigating the rate of increase of underground temperatures, for securing an international geological map of Europe, for reporting on erratic blocks of England, Wales, and Ireland, for examining marine life on coasts and rivers of North America, for survey of Palestine, and for science teaching in elementary schools. A vote was passed that the Council be recommended to request the Admiralty to adopt an harmonic analysis for the reduction of tidal observations. This is already being done in Germany, France, India, and elsewhere. A letter was read on the subject prepared by Sir William Thomson and Prof. G. H. Darwin to send to the Admiralty. The Council was also recommended to request the Canadian Government to adopt measures for investigating the physical character, languages, social and artistic condition of the native tribes of the Dominion. Various American members having suggested that an International Scientific Congress be formed, this subject was referred to the Committee by several Sections.

The General Committee adjourned to meet in London on November 11.

The closing meeting of the Association was held in Queen's Hall the same afternoon. There was a large attendance, Lord Rayleigh being in the chair. Admiral Ommanney, the acting treasurer, announced the membership, and also the total receipts, which have been about 1800*l.* The suggestion as to an International Scientific Congress was received with applause.

The Corporation and Faculty of McGill University were on the platform, and Sir William Dawson, the Principal, after a brief preliminary address, conferred the honorary degree of LL.D. upon the leading members of the Association, whose names have already been given. As the diplomas were delivered, warm applause greeted each recipient.

Lord Rayleigh thanked the University for the honours conferred and also for the splendid hospitality given to the Association, the recollection of which they would retain during the remainder of their lives. He said that no previous meeting had been so well provided with meeting-rooms as the University furnished. As a slight token of acknowledgment for Montreal's reception, the Association had provided a gold medal and endowment for McGill University, although he felt they could never fully appreciate the generosity of their hosts.

Sir Richard Temple moved, and Prof. Boyd Dawkins seconded, a resolution expressing cordial sympathy with the popular movement set on foot in Montreal to establish a public library worthy of the great city to properly mark the occasion of the first meeting of the British Association in Canada. Both made brief addresses, urging the members to aid the project. Sir William Thomson spoke in its advocacy, saying that a good library would be of vast importance to Montreal and to this portion of North America, that it would be an excellent basis for the subsequent establishment of a good scientific school. He urged the members to give liberal subscriptions. The resolution was adopted amid applause.

Sir Lyon Playfair moved, and General Lefroy seconded, a resolution of cordial thanks to the Dominion Government for the aid, support, and sympathy shown in promoting the Montreal meeting of the British Association, and for the warm interest felt in its success, which was adopted. Mr. J. White, a member of the Canadian House of Commons, responded for the Dominion Government.

Sir William Thomson moved, and Sir Frederick Bramwell seconded, a resolution of thanks to the McGill University, the Corporation of Montreal and its citizens, with a long list of other bodies who aided in promoting the objects of the meeting. Sir James Ferrier responded, saying, in the course of a felicitous address, that already the projected public library had been fairly started by a proposed gift to McGill College for this purpose, by a benevolent gentleman of Montreal, of $50,000.

Other votes of thanks were passed to railway, steamer, and telegraph companies, and others who have aided the meeting. Mr. Hugh M'Lennan and Mr. Andrew Robertson responded for them.

The final vote of thanks to the President was moved by Prof. Daniel Wilson and seconded by Prof. Robert Ball and Sir William Dawson. After a brief appropriate reply by Lord Rayleigh, the British Association adjourned, to meet at Aberdeen in 1885.

About 300 British and Canadian members of the Association have arrived in Philadelphia from Montreal to attend the meetings of the American Association for the Advancement of Science. A local hospitality committee received them at the railway stations, providing homes for them with citizens or in hotels. They were formally welcomed to Philadelphia at a large meeting at the Academy of Music on Friday night. Mr. John Welsh, formerly Minister to England, delivered an address as chairman of the local committees, and Provost Pepper, of the University of Pennsylvania, made a special address of welcome, to which Prof. Robert S. Ball replied for the British Association. A members' promenade reception and banquet followed. The British guests were given excursions on Saturday to the Atlantic sea-coast resorts near Philadelphia; also by the Pennsylvania Railroad to Cresson, at the summit of the Alleghany Mountains; also by the Reading Railroad through the anthracite coal regions of Pennsylvania.

The American Association has appointed a Committee to confer with a similar Committee of the British Association relative to arranging for the proposed International Scientific Congress referred to in the closing proceedings of the British Association at Montreal.

SECTION E

GEOGRAPHY

Opening Address by General Sir J. H. Lefroy, R.A., C.B., K.C.M.G., F.R.S., F.S.A., V.P.R.G.S., President of the Section

Man's acquaintance with the planet he inhabits, with the earth which he is to replenish and to subdue, has been a thing of growth so slow, and is yet so imperfect, that we may look to a far distant day for an approach to a full knowledge of the marvels it offers, and the provision it contains for his well-being. He has seen, as we now generally believe, in silent operation, the balanced forces which have replaced the glacier by the forest and the field; which have carved out our present delights of hill and dale in many lands, and clothed them with beauty; and it may be that changes as great will pass over the face of the earth before the last page of its history is written in the books of eternity. But it is no longer before unobservant eyes that the procession of ages passes. Geography records the onward march of human families; often by names which survive them it rears enduring monuments to great discoverers, leaders, and sufferers; it is an indispensable minister to our every-day wants and inquiries; but beyond this it satisfies one of the most widely diffused and instinctive cravings of the human intelligence, one which from childhood to maturity, from maturity to old age, invests books of travels with an interest belonging to no other class of literature. If "the proper study of mankind is man," where else can we learn so much about him, or be presented with such perplexing problems, such diversity in unity, such almost incredible contrasts in the uses of that noble reason, that Godlike apprehension, which our great poet attributes to him? or see the "beauty of the world, the paragon of animals" (*Hamlet*, Act. ii. Sc. 2) in conditions so unlike his birthright? Geography, then, is far from being justly regarded as a dry record of details which we scarcely care to know, and of statistics which are often out of date.

It is scarcely necessary to do more than allude here to the intimate relations between geography and geology. The changes on the earth's surface effected within historical times by the operation of geological causes, and enumerated in geological books, are far more numerous and generally distributed than most persons are aware of; and they are by no means confined to sea-coasts, although the presence of a natural datum in the level of the sea makes them more observed there. A recent German writer, Dr. Hahn, has enumerated ninety-six more or less extensive tracts known to be rising or sinking. We owe to Mr. R. A. Peacock the accumulation of abundant evidence that the island of Jersey had no existence in Ptolemy's time, and probably was not wholly cut off from the Continent before the fourth or fifth century. Mr. A. Howarth has collected similar proofs as to the Arctic regions; and every fresh discovery adds to the number. Thus the gallant, ill-fated De Long, a name not to be mentioned without homage to heroic courage and almost superhuman endurance, found evidence that Bennett Island has risen a hundred feet in quite recent times. Nordenskjöld found the remains of whales, evidently killed by the early Dutch fishers, on elevated terraces of Martin's Island. The recent conclusion of Prof. Hull, that the land between Suez and the Bitter Lakes has risen since the Exodus, throws fresh light on the Mosaic account of that great event; and to go still further south, we learn from the Indian Survey that it is "almost certain" that the mean sea-level at Madras is a foot lower, *i.e.* the land a foot higher, than it was sixty years ago. If I do not refer to the changes on the west side of Hudson's Bay, for a distance of at least six hundred miles, it is only because I presume that the researches of Dr. Robert Bell are too well known here to require it. Any of my hearers who may have visited Bermuda are aware that so gently has that island subsided, that great hangings of stalactite, unbroken, may be found dipping many feet into the sea, or, at all events, into salt-water pools standing at the same level, and we have no reason to suppose the sinking to have come to an end. We learn from the Chinese annals that the so-called Hot Lake Issyk-kul, of Turkestan, was formed by some convulsion of nature about 160 years ago (*Proc. R.G.S.* vol. xviii. p. 250), and there seems no good reason to reject the Japanese legend that Fusiyama itself was suddenly thrown up in the third century before our era (B.C. 286). These are but illustrations of the assertion I began with, that geography and geology are very nearly connected, and it would be equally easy to show on how many points we touch the domain of botany and natural history. The flight of birds has often guided navigators to undiscovered lands. Nordenskjöld went so far as to infer the existence of "vast tracts, with high mountains, with valleys filled with glaciers, and with precipitous peaks," between Wrangel Land and the American shores of the Polar Sea, from no other sign than the multitudes of birds winging their way northward in the spring of 1879, from the *Vega's* winter quarters. The walrus-hunters of Spitzbergen drew the same conclusion in a previous voyage from the flight of birds towards the Pole from the European side. Certainly no traveller in the more northern latitudes of this continent in the autumn, can fail to reflect on the ceaseless circulation of the tide of life in the beautiful harmony of Nature, where he finds that he can scarcely raise his eyes from his book at any moment, or direct them to any quarter of the heavens, without seeing countless numbers of wild fowl, guided by unerring instinct, directing their timely flight towards the milder climates of the South.

To address you on the subject of geography, and omit mention of the progress made within these very few years in our knowledge of the geography of this Dominion, might indeed appear an unaccountable, if not an unpardonable, oversight; nevertheless, I propose to touch upon it but briefly, for two reasons: first, I said nearly all I have to say upon a similar occasion four years ago; secondly and chiefly, because I hope that some of those adventurous and scientific travellers who have been engaged in pushing the explorations of the Geological Survey and of the Canada Pacific Railway into unknown regions will have reserved some communications for this Section. Canada comprises within its limits two spots of a physical interest not surpassed by any others on the globe. I mean the pole of vertical magnetic attraction, commonly called the magnetic pole; and the focus of greatest magnetic force, also often, but incorrectly, called a pole. The first of these, discovered by Ross in 1835, was revisited in May 1847 by officers of the Franklin Expedition, whose observations have perished, and was again reached or very nearly so by McClintock in 1859, and by Schwatka in 1879; neither of these explorers, however, was equipped for observation. The utmost interest attaches to the question whether the magnetic pole has shifted its position in fifty years, and although I am far from rating the difficulty lightly, it is probably approachable overland, without the great cost of an Arctic expedition. The second has never been visited at all, although Dr. R. Bell, in his exploration of Lake Nipigon, was within 200 miles of it, and the distance is about the same from the Rat Portage. It is in the neighbourhood of Cat Lake. Here then we have objects worthy of a scientific ambition and of the energies of this young country, but requiring liberal expenditure and well-planned efforts, continued steadily, at least in the case of the first, for, perhaps, three or four years. Of objects more exclusively geographical, to which it may be hoped that this meeting may give a stimulus, I am inclined to give a prominent place to the exploration of that immense tract of seventy or eighty thousand square miles, lying east of the Athabasca River, which is still nearly a blank on our maps, and in connection with such future exploration I cannot omit to mention that monument of philological research, the "Dictionary of the Languages of the native Chipewyans, Hare Indians, and Loucheux," lately published by the Rev. E. Petitot. The lexicon is preceded by an introduction, giving the result of many years' study among these people of the legends or traditions by which they account for their own origin. M. Petitot, who formerly was unconvinced of their remote Asiatic parentage, now finds abundant proof of it. But perhaps his most interesting conclusion is that in these living languages of the extreme north, we have not only the language of the *Nabajos*, one of the Apache tribes of Mexico, which has been remarked as linguistically distinct from the others, but also the primitive Aztec tongue, closely resembling the language of the Incas, the Quichoa, still spoken in South America. I need not say how greatly these relations, if sustained by the conclusions of other students, are calculated to throw light upon the profoundly interesting question of the peopling of America.

This is perhaps a proper occasion to allude to a novel theory proposed about two years ago, with high official countenance, upon a subject which will never cease to have interest, and perhaps never be placed quite beyond dispute. I mean the landfall, as it is technically called, of Columbus, in 1492. The late Captain G. V. Fox, of the Admiralty, Washington, argued in a carefully-prepared work, that Atwood's Key, erroneously called Samana on many charts, is the original Guanahari of Columbus, renamed by him S. Salvador, also that Crooked Island and Acklin Island are the Maria de la Concepcion of Columbus and the true Samana of succeeding navigators in the sixteenth century. The last supposition is unquestionably correct. Crooked, Acklin, and Fortune Islands, which from the narrowness of the channels dividing them may have been, and very probably were, united four centuries ago, are plainly the Samana of the Dutch charts of the seventeenth century, and are so named on the excellent chart engraved in 1775 for Bryan Edwards's "History of the West Indies," but the view that Atwood's Key is identical with Guanahari is original, and is neither borne out by any old chart, nor by Columbus's description. This small island is conspicuously wanting in the one physical feature by which Guanahari is to be identified "*una laguna en medio muy grande.*" There is no lake or lagoon in it, nor does its distance from Samana tally at all with such slender particulars as have been left us by Columbus respecting his proceedings. The name S. Salvador has attached, not to Atwood's Key, but to Cat Island, one of the Bahamas; it is true that modern research has shifted it, but only to the next island, and on very good grounds. Cat Island is not *muy llana*, very level; on the contrary, it is the most hilly of all the Bahamas, and it has no lake or lagoon. Watling Island, a little to the south-east of Cat Island, and now generally recognised as the true Guanahari or S. Salvador, is very level; it has a large lagoon, it satisfies history as to the proceedings of Columbus for the two days following his discovery, by being very near the numerous islands of Exuma Sound, and I think few impartial persons can doubt the justice of the conclusion of the late Admiral Becher and of Mr. Major as to its identity; there are difficulties in the interpretation of Columbus's log on any hypothesis, but there is one little "undesigned coincidence" which to my mind goes far to carry conviction. Columbus, when he sighted land, was greatly in want of water, and he continued cruising about among the small islands in search of it for some days. Clearly, therefore, the *laguna* on Guanahari was not a fresh-water lake; nor is the lagoon on Watling Island fresh water, and so it exactly meets the case.

The report of Lieut. Raymond P. Rodgers, of the United States Navy, on the state of the Canal Works at Panama so lately as January 25 last, which has doubtless been eagerly read by many present, leaves me little to say on that great enterprise. Perhaps the following official returns of the amount of excavation effected in cubic metres (a cubic metre is 1·308 cubic yards) will enable the audience to realise its progress:—

		Total excavated	In each month
1883	October	2,042,034	
1883	November	2,375,534	333,300
1883	December	2,760,534	385,000
1884	January	3,340,534	580,000
1884	February	3,974,191	633,657
1884	March	4,590,022	615,831

The total quantity of excavation to be done in a length of 46·6 miles is estimated at 100,000,000 cubic metres, but the rapid augmentation of quantity shows that the limit has not been attained. This is no place to speak of the stimulus given by this great work to mechanical invention or the gigantic power of the machines employed, which will probably receive attention in another Section, but I may mention the two great problems which still await solution. The first is how to deal with the waters of the River Chagres; the second is how to manage a cutting nearly 400 feet deep (110 m. to 120 m.). The Chagres is a river as large as the Seine, but subject to great fluctuations of volume; it cuts the line of the canal nearly at right angles, and for obvious reasons it is impossible to let it flow into it. It is proposed to arrest the stream by an enormous dyke at Gamboa, near the divide. It will cross a valley between two hills, and be 1050 yards long at the bottom, 2110 yards at the top, 110 yards thick at the base, and 147 feet in greatest height. Out of the reservoir so constructed it is proposed to lead the overflow by two artificial channels, partly utilising the old bed. The cutting will be nearly 500 feet wide at the top (150 m.), with the sides at a slope of ¼. It is proposed to attack it by gangs or parties working on twelve different levels at the same time, one each side of the summit, dividing the width at each level into five parallel sections. Thus there will be 120 gangs at work together, and it is confidently hoped that the whole will be really finished in 1888, the date long since assigned for its completion by M. de Lesseps. There is practically no other project now competing with it: for the proposed routes by the Isthmus of Tehuantepec, the Atrato, and San Blas, may be regarded as almost universally given up; both the latter would involve the construction of ship tunnels on a scale to daunt the boldest engineer. The so-called Caledonia route has not stood the test of examination. There remains but the Nicaragua route, and this, while practicable enough, has failed to attract capitalists, and is environed by political and other difficulties, which would leave it, if completed, under many disadvantages as compared with its rival. Among the latter must be named the necessity for rising by locks to the level of the Lake of Nicaragua (108 feet).

It is very tempting to speculate on the probable consequences of bringing the Hispano-Indian Republics bordering on the Pacific into such early contact with the energies of the Old World, but these speculations belong to politics rather than geography; moral transformations, we know, are not effected so easily as the conquest over physical difficulties.

Sir J. H. Lefroy then alluded at some length to recent progress in African exploration; then turning to Central Asia he went on:—

The Russian project for diverting the Oxus or Amu Darya from the Sea of Aral into the Caspian, remains under investigation. We learn from the lively account of Mr. George Kennan, a recent American traveller, that there is more than one motive for undertaking this great work, if it shall prove practicable. He states that the lowering of the level of the Caspian Sea, in consequence of the great evaporation from its surface, is occasioning the Russian Government great anxiety, that the level is steadily but slowly falling, notwithstanding the enormous quantity of water poured in by the Volga, the Ural, and other rivers. In fact, Col. Venukof says that the Caspian is drying up fast, and that the fresh-water seals, which form so curious a feature of its fauna, are fast diminishing in number. At first view there would not appear great difficulty in restoring water communication, the point where the river would be diverted being about 216 feet above the Caspian; but accurate levelling has shown considerable depressions in the intervening tract. As the question is one of great geographical interest we may devote a few minutes to it. It is not to be doubted that the Oxus, or a branch of it, once flowed into the Caspian Sea. Prof. R. Lenz, of the Russian Académie Impériale des Sciences, sums up his investigation of ancient authorities by affirming that there is no satisfactory evidence of its ever having done so before the year 1320;

passages which have been quoted from Arab writers of the ninth century only prove, in his opinion, that they did not discriminate between the Caspian Sea and the Sea of Aral. There is evidence that in the thirteenth and fourteenth centuries the river bifurcated, and one branch found its way to the Caspian, but probably ceased to do so in the sixteenth century. This agrees with Turcoman traditions. Even so late as 1869 the waters of the Oxus reached Lake Sara Kamysh, 80 or 90 miles from their channel, in a great flood, as happened also in 1850, but Sara Kamysh is now some 49 feet lower than the Caspian, and before they could proceed further an immense basin must be filled. The difficulties then of the restoration by artificial means of a communication which natural causes have cut off, are (*a*) the disappearance of the old bed, which cannot be traced at all over part of the way; (*b*) the possibility that further natural changes, such as have taken place on the Syr-Daria, may defeat the object; (*c*) the immense expenditure under any circumstances necessary, the distance being about 350 miles, which would be out of all proportion to any immediate commercial benefit to be expected. We may very safely conclude that the thing will not be done, nor is it at all probable that Russian finances will permit the alternative proposal of cutting a purely artificial canal by the shortest line, at an estimated expense of 15,000,000 to 20,000,000 roubles.

We have had, I think, no news of the intrepid Russian traveller, Col. Prjevalsky, who started from Kiakhta on November 20, of later date than January 20, when he had reached Alashan, north of the Great Wall. He had for the third time crossed the great Desert of Gobi, where he experienced a temperature below the freezing-point of mercury, and was to start for Lake Kuku-nor (+ 10,500 feet) the following day, thence to proceed to Tsaidam, where he proposed to form a depot of stores and provisions, and, leaving some of his party here, to endeavour to reach the sources of the Yang-tse-kiang, or Yellow River. It was his intention to devote the early part of the present summer to exploration of the Sefani country, situated between Kuku-nor to the north and Batan to the south —a country likely to yield an abundant harvest of novelty in natural history—afterwards to transfer his party to Hast, in Western Tsaidam, which may be reached next spring. From this point the expedition will endeavour first to explore Northern Thibet, which is his main object, in the direction of Lhasa and Lake Tengri-nor, and then returning northward, cross the Thibet plateau by new routes to Lake Lob-nor. After the reassembly of the expedition at this point, it will probably regain Russian territory at Issyk-kul. Col. Prjevalsky is accompanied by two officers, an interpreter, and an escort of twenty Cossacks.

As you are aware, we have been chiefly indebted to natives of India for several years past for our knowledge of the regions beyond the British boundary. Mr. McNair, of the Indian Survey Department, who received the Murchison premium of this year, is the first European who has ever penetrated so far as Chitral, which is only 200 miles from Peshawur. In various disguises, however, natives, carefully instructed, have penetrated the neighbouring but unneighbourly regions of Afghanistan, Kashmir, Turkestan, Nepaul, Thibet—in almost every direction —and these achievements were crowned by one of them, known as A-k, reaching Saitu or Sachu, in Mongolia, in 1882, and thence returning in safety to India, after an absence of four years. His route took him to Darchendo or Tachialo (lat. 31°), the most westerly point reached by the late Capt. W. J. Gill, R.E., in 1877, and thus connects the explorations of that accomplished and lamented traveller with Central Asia. A-k has brought fresh evidence that the Sanpoo and the Brahmapootra are one; the quite modern opinion that the former flows into the Irrawaddy being shown to be groundless. After draining the northern slopes of the Himalayas, the Brahmapootra makes a loop round their eastern flanks where it has been called the Dehang, and thence, as everybody knows, flows westerly to join the Ganges; the maps have been shown in this instance to be right. The travels of these native explorers, their stratagems and their disguises, their hazards and sufferings, their frequent hair-breadth escapes, are teeming with excitement. One of them describes a portion of his track at the back of Mount Everest, as carried for a third of a mile along the face of a precipice at a height of 1500 feet above the Bhotia-kosi River, upon iron pegs let into the face of the rock, the path being formed by bars of iron and slabs of stone stretching from peg to peg, in no place more than 18 inches, and often not more than 9 inches, wide. Nevertheless this path is constantly used by men carrying burdens.

One of the finest feats of mountaineering on record was performed last year by Mr. W. W. Graham, who reached an elevation of 23,500 feet in the Himalayas, about 2900 feet above the summit of Chimborazo, whose ascent by Mr. Whymper in 1880 marked an epoch in these exploits. Mr. Graham was accompanied by an officer of the Swiss army, an experienced mountaineer, and by a professional Swiss guide. They ascended Kabru, a mountain visible from Darjeeling, lying to the west of Kanchinjunga, whose summit still defies the strength of man.

And here I may refer to that great work, the Trigonometrical Survey of India. The primary triangulation, commenced in the year 1800, is practically completed, although a little work remains to extend it to Ceylon on one side and to Siam on the other. Much secondary triangulation remains to be executed, but chiefly outside the limits of India proper. The Pisgah views, by which some of the loftiest mountains in the world have been fixed in position, sometimes from points in the nearest Himalayas, 120 miles distant, only serve to arouse a warmer desire for unrestrained access. The belief long entertained that a summit loftier than Mount Everest exists in Thibet is by no means extinct, but it is possible that the snowy peak intended may prove eventually to be the Mount Everest itself of the original Survey. Still, however, science, in spite of fanatical obstruction, makes sure advances. The extraordinary learning and research by which Sir H. Rawlinson was enabled a few years since to expose a series of mystifications or falsifications relating to the Upper Oxus, which had been received on high geographical authority, can never be forgotten. That river has now been traced from its sources in the Panjab, chiefly by native explorers, and to them we may be said to be indebted for all we know of Nepaul, from which Europeans are as jealously excluded as they are from the wildest Central Asian Khanate, although Nepaul is not so far from Calcutta as Kingston is from Quebec.

Carrying their instruments to the most remote and inaccessible places, and among the most primitive hill tribes, the narrative reports of the officers of the Indian Survey are full of ethnographic and other curious information. Take for example the account given by Mr. G. A. McGill, in 1882, of the Bishnoies of Rajpútana, a class of people, he says, who live by themselves, and are seldom to be found in the same village with the other castes. "These people hold sacred everything animate and inanimate, carrying this belief so far that they never even cut down a green tree; they also do all in their power to prevent others from doing the same, and this is why they live apart from other people, so as not to witness the taking of life. The Bishnoies, unlike the rest of the inhabitants, strictly avoid drink, smoking, and eating opium; this being prohibited to them by their religion. They are also stringently enjoined to monogamy and to the performance of regular ablutions daily. Under all these circumstances, and as may be expected, the Bishnoies are a well-to-do community, but are abhorred by the other people, especially as by their domestic and frugal habits they soon get rich, and are the owners of the best lands in the country."

In one particular the experience of the Indian Survey carries a lesson to this country. "A constantly growing demand," says Gen. Walker, "has risen of late years for new surveys on a large scale, in supersession of the small-scale surveys which were executed a generation or more ago. . . . The so-called topographical surveys of those days were in reality geographical reconnaissances sufficient for all the requirements of the Indian atlas, and for general reproduction on small scales, but not for purposes which demand accurate delineation of minute detail." We have in the Canadian North-West a region which has not yet passed beyond the preliminary stage, and it would probably be possible to save much future expenditure by timely adoption of the more rigorous system. There is perhaps no region on the globe which offers conditions more favourable for geodesy than the long stretch of the western plains, or where the highest problems are more likely to present themselves in relation to the form and density of the earth. The American surveyors have already measured a trigonometrical base of about 10·86 miles in the Sacramento Valley, the longest I believe as yet measured in any country (the Yolo Base) and reported to be one of the most accurate.

The President then referred to Australian exploration, the International Polar Expeditions, deep-sea research, and railway extension, and concluded as follows :—

I have now touched lightly upon all the points which appear to me to be most noticeable in the recent progress of geographical science; but before I resume my seat I cannot deny myself the pleasure of alluding to that important measure of social reform, so simple in its application, so scientific in its basis, for which you are indebted to the perseverance and enthusiasm of my friend Mr. Sandford Fleming, C.E. I mean, of course, the agreement to refer local time on this continent to a succession of first meridians, one hour apart. There are many red-letter days in the almanac of less importance than that memorable November 18, 1883, which saw this system adopted, whether we consider its educational tendency or its influence on the future intercourse of unborn millions. It is a somewhat memorable evidence also that agreement upon questions of general concern is not that unattainable thing which we are apt to consider it. The next step will not be long delayed; that is the agreement of the civilised world to use one first meridian—Paris, Ferrol, Washington, Rio de Janeiro, gracefully, as I venture to hope, giving that precedency to Greenwich which is demanded by the fact that an overwhelming proportion of the existing nautical charts of all nations, and of maps and atlases in most of them, already refer their longitudes to that meridian; no other change would be so easy or so little felt.

SECTION G

MECHANICAL SCIENCE

OPENING ADDRESS BY SIR F. J. BRAMWELL, F.R.S., V.P.INST.C.E., PRESIDENT OF THE SECTION

IN a family of seven children there are two who are of paramount importance: the eldest, at the one end of the scale, important because he is the heir, the first-born; and at the other end of the scale, the little Benjamin, important because he is the last, the youngest, and the dearest. The position of little Benjamin is not, perhaps, quite as honourable as that of the heir, and not, when the family breaks up, by any means as good; but while the family holds together, Benjamin receives an amount of attention and consideration that does not fall to the lot of any one of the intermediates, not even to the heir himself. But there is one risk about Benjamin's position, a risk that cannot appertain to the post of the first-born; little Benjamin may be deposed by the advent of a lesser Benjamin than himself, whereas the first-born becomes (if possible) still more the first-born for each addition to the family. Perhaps some of you may say, Be it so; but what has this to do with the address of the President of Section G? Those who make this inquiry, however, certainly have not present to their minds the change that has this year taken place. Up to and including the Southport meeting, Section G was the little Benjamin among the seven sons of the B.A. (I will not waste your time by giving the name of the Association in full, nor will I affront you by using an abbreviation which is occasionally improperly applied), but at Montreal appears Section H, and G becomes relegated among those uninteresting members of the family who are neither the important head nor the cherished tail. I grieve for Benjamin, and I think the present occasion an apt one for magnifying Section G. Apt for two reasons: the foregoing one, that H has deposed it from its position; the other, that we are meeting in Montreal—and in reference to this latter reason let me ask, Is it not the fact that to the labours of the men who have been, or are (or ought to be) members of Section G is due the possibility of the meeting taking place on this side of the Atlantic?

At our jubilee meeting at York, I called the attention of the Section to the fact that in 1831, when the Association first met in that city, they arrived there laboriously by the stage-coach, and that practically the Manchester and Liverpool, the Stockton and Darlington, and some few others, were the only railways then in existence. I also called their attention to the fact that in 1831 there were but very few steamers. I find the total number registered in the United Kingdom in that year was only 447. If under this condition of things the proposition had been made in 1832 at Oxford, as it was made in 1882 at Southampton, that the next meeting but one of the Association should take place in Montreal, the extreme probability is that the proposer would have been safely lodged in a lunatic asylum for suggesting that that which might have involved a six-weeks' voyage out, and a four-weeks' voyage back, could ever be seriously entertained. Further, to give once more the hackneyed quotation, some few years after this, *i.e.* in 1836, Dr. Lardner established, to his own satisfaction conclusively, that no vessel could ever steam across the Atlantic the whole way—a striking instance of the mistakes made by scientific speculation—a branch of science widely differing in the value of its results from those branches which deal with absolute demonstration. Undeterred, however, by such adverse opinion, the engineers "kept on pegging away," experimenting, improving, and progressing, until the scientific speculation was met with the hard fact of the Atlantic voyage steamed the whole way by the *Sirius* and by the *Great Western* in 1838. The impossible was proved to be the possible, and from that day to this the advancement of steam ocean navigation has continued. The six-weeks' voyage, sailing westward, of the year 1831, has become converted into but little over six days. And thus it is that that which would have been a mad proposition in the year 1832 became a perfectly rational one in 1882; and the deliberations of the General Committee on the proposition were not directed as to whether it would be possible to convey the members with certainty, expedition, and economy across the Atlantic, but as to whether it was expedient or not on general grounds to hold for the first time a meeting of the British Association elsewhere than in some city of the United Kingdom. I say again that the possibility of such a meeting is absolutely due to the engineer, and that therefore, on this ground, the present is an appropriate occasion to magnify G, the Mechanical Section of this Association.

It is true that the man who looks only at that which is on the surface may say, "You arrogate too much to yourselves. You ignore (to which I say, Heaven forbid!) the skill and daring of your sailors. You ignore commercial enterprise. You ignore the development of iron and steel manufacture, which have enabled you to build the steamers of the present day. You ignore the increased output of the best steam coal in the world, and you attribute the whole result to the engineer." Such an objector would be in the condition of that man who, in answer to George Stephenson's question, "What is causing that railway train to move?" said, "Why, I suppose the coal that is burning in the locomotive;" and who was met by that grand and comprehensive answer, that it was the "Sun," for the coals were a consequence, and not a first cause. Similarly I venture to say that the mechanical engineer may lay claim to be the central source which has vivified and given rise to the improvements in the manufacture of iron and steel, in the construction of engines, and in the development of our collieries.

There are those I know who object that Section G deals too little with pure science, too much with its applications. It may be, as the members of Section G might retort, that it is possible to attend so much to pure science as to get into the unchecked region of scientific speculation, and that, had the members of Section G been debarred from the application of science, the speculation of Dr. Lardner might to the present day have been accepted as fact.

I have quoted it before, but it has so important a bearing on this point, and comes from a man of such high authority, that I cannot refrain from once more giving you Dr. Tyndall's views on this question:—

"The knowledge of Nature and the progressive mastery over the powers of Nature imply the interaction of two things—namely, thought conceived and thought executed; the conceptions of the brain, and the realisation of those conceptions by the hand. The history of the human intellect hardly furnishes a more striking illustration of this interaction of thought and fact than that furnished by the Association of Physics and Engineering. Take for instance the case of steam. Without knowing its properties, the thought of applying steam could not have arisen, hence the first step was physical examination. But that examination suggested practice, and the steam-engine at last saw the light; thus experimental physics was the seedling from which the steam-engine sprang. But the matter did not end here; the positions of debtor and creditor were soon reversed, for the stupendous operations of the steam-engine forced men of thoughtful philosophic minds to inquire into the origin of the power of steam. Guess succeeded guess, inspiration succeeded inspiration; the ever-present fact of our railways, and our power-looms, and our steamships gave the mind no rest until it had answered the question, How are heat and steam, its instruments, related to mechanical power? Had the works of the engineer not preceded the work of the natural philosopher, this question would never have been asked with the emphasis, nor pursued with the vigour, nor answered with the success, which have attended it. It was the intellectual activity excited by the work which the civil engineers of England had accomplished that gave to philosophy the theory of the conservation of energy, including the dynamical theory of heat. . . . The engineering genius of the future is certain to derive from this theory strength and guidance. Thus necessarily has thought originated fact, and fact originated thought. In the development of science these two powers are coequal; each in turn ceasing to be a consequence, and becoming a creative cause. The Atlantic cable also had its small beginnings in the laboratory of the physical inquirer. Here, as before, experimental physics led the way to engineering facts of astounding magnitude and skill. But here also the positions of debtor and creditor have been reversed, for the work of the engineer has caused the physical inquirer to pursue his investigations with a thoroughness and vigour, and has given to those investigations a scope and magnitude, which, without the practical stimulus, would have been impossible. The consequence is that the practical realisation of sending electric messages along the bottom of the Atlantic has been an immense augmentation of our knowledge regarding electricity itself. Thus does the human intelligence oscillate between sound theory and sound practice, gaining by every contact with each an accession of strength. These two things are the soul and body of science. Sever sound theory from sound practice, and both die of atrophy. The one becomes a ghost and the other becomes a corpse."

I think all men, even although they be followers of science in its purest and most abstract form, must agree that these words are words of sound sense, well worthy of being borne in mind and of being acted on, and will, therefore, concur in the propriety of Section G dealing with engineering subjects generally as well as with abstract mechanical science. Once admitting this, I may ask—certain what the answer must be—whether there is any body of men who more appreciate and make greater use of the applications of pure science than do the members of this Section. Surely every one must agree that we engineers are those who make the greatest practical use not only of the science of mechanics but of the researches and discoveries of the members of the other Sections of this Association.

Section A, *Mathematical and Physical Science.* The connection between this Section and Section G is most intimate. With any ordinary man I should have referred, in proof of this intimate connection, to the fact that the President of A this year is a member of the Council of the Institution of Civil Engineers, but when I remind you that it is Sir William Thomson who fills this double office, you will see that no deduction such as I have hinted at can be drawn from his dual functions, because the remarkable extent and versatility of his attainments qualify him for so many offices, that the mere fact of his holding some one double position is no certain evidence of the intimate connection between the two. But setting aside this fact of the occupancy of the chair of A by a civil engineer, let us remember that the accomplished engineer of the present day must be one well grounded in thermal science, in electrical science, and for some branches of the profession in the sciences relating to the production of light, in optical science, and in acoustics; while, in other branches, meteorological science, photometrical science, and tidal laws are all-important. Without a knowledge of thermal laws, the engineer engaged in the construction of heat-motors, whether they be the steam-engine, the gas-engine, or the hot-air engine, or engines depending upon the expansion and contraction under changes of temperature of fluids or of solids, will find himself groping in the dark; he will not even understand the value of his own experiments, and therefore will be unable to deduce laws from them; and if he makes any progress at all, it will not guide him with certainty to further development, and it may be that he will waste time and money in the endeavour to obtain results which a knowledge of thermal science would have shown him were impossible. Furnished, however, with this knowledge, the engineer, starting with the mechanical equivalent of heat, knowing the utmost that is to be attained, and starting with the knowledge of the calorific effect of different fuels, is enabled to compare the results that he obtains with the maximum, and to ascertain how far the one falls short of the other; he sees even at the present day that the difference is deplorably large, but he further sees in the case of the steam-engine, that which the pure scientist would not so readily appreciate, and that is, how a great part of this loss is due to the inability of materials to resist temperature and pressure beyond certain comparatively low limits; and he thus perceives that unless some hitherto wholly unsuspected, and apparently impossible, improvement in these respects should be made, practically speaking the maximum of useful effect must be far below that which pure science would say was possible. Nevertheless, he knows that within the practical limits great improvements can be made; he can draw up a debtor and creditor account, as Dr. Russell and myself have done, and as has been done by Mr. William Anderson, the engineer, in the admirable lecture he gave at the Institution of Civil Engineers in December last, on "The Generation of Steam and the Thermodynamic Principles involved." Furnished with such an account the engineer is able to say, in the language of commerce, I am debtor to the fuel for so many heat-units, how, on the credit side of my account, do I discharge that debt? Usefully I have done so much work, converted that much heat into energy. Uselessly I have raised the air needed for combustion from the temperature of the atmosphere to that of the gases escaping by the chimney; and he sets himself to consider whether some portion of the heat cannot be abstracted from these gases and be transmitted to the in-coming air. As was first pointed out by Mr. Anderson, he will have to say a portion of the heat has been converted into energy in displacing the atmosphere, and that, so far as the gaseous products of the coal are concerned, must, I fear, be put up with. He will say, I have allowed more air than was needed for combustion to pass through the fuel, and I did it to prevent another source of loss—the waste which occurs when the combustion is imperfect; and he will begin to direct his attention to the use of gaseous or of liquid fuel, or of solid fuel reduced to fine dust, as by Crampton's process, as in these conditions the supply may be made continuous and uniform, and the introduction of air may be easily regulated with the greatest nicety. He will say, I am obliged to put among my credits—loss of heat by convection and radiation, loss by carrying particles of water over with the steam, loss by condensation within the cylinder, loss by strangulation in valves and passages, loss by excessive friction or by leakage; and he will as steadily apply himself to the extinction or the diminution of all such causes of loss as a prudent Chancellor of the Exchequer would watch and cut down every unproductive and unnecessary expenditure. It is due to the guidance of such considerations as these that the scientific engineer has been enabled to bring down the consumption of fuel in the steam-engine, even in marine engines such as those which propelled the ship that brought us here, to less than one-half of that which it was but a few years back. It is true that the daily consumption may not have been reduced, that it may be even greater, but if so it arises from this, that the travelling public will have high speed, and at present the engineer, in his capacity of naval architect, has not seen how—notwithstanding the great improvements that have been made in the forms of vessels—to obtain high speed without a large expenditure of power. I anticipate, from the application of thermal science to practical engineering, that great results are before us in those heat-motors, such as the gas-engine, where the heat is developed in the engine itself. Passing away from heat-motors, and considering heat as applied to metallurgy, from the time of the hot blast to the regenerative furnace, it is due to the application of science by the engineer that the economy of the hot blast was originated, and that it has been developed by the labours of Lowthian Bell, Cowper, and Cochrane. Equally due to this application are the results obtained in the regenerative furnace, in the dust furnace of Crampton, and in the employment of liquid fuel, and also in operations connected with the rarer metals, the oxygen furnace, and the atmospheric gas furnace, and, in its incipient stage, the electrical furnace. To a right knowledge of the laws of heat and to their application by the engineer, must be attributed the success that has attended the air-refrigerating machines, by the aid of which fresh meat is, at the end of a long voyage, delivered in a perfect condition; and to this application we owe the economic distillation of sea-water by repeated ebullitions and condensations at successively decreasing temperatures, thus converting the brine that caused the Ancient Mariner to exclaim, "Water, water everywhere, nor any drop to drink," into the purest of potable waters, and thereby rendering the sailor independent of fresh-water storage.

With respect to the application by the engineer of electrical science, it is within the present generation that electricity has passed from the state of a somewhat neglected scientific abstraction into practical use: first, by the establishment of the land telegraph, then by the development into the submarine cable, by means of which any one of us visitors here in Canada may be in instant communication with his own country, and may be so without a selfish exclusive occupation of the cable, for once more the application of science has solved that apparently impossible problem of employing a single wire to be at one and the same time the transmitter of multiple electric messages, and messages in opposite directions. Then, thanks to the application of Faraday's great discovery of induced electricity, there has been, during the last quarter of a century, the progressive development of the dynamo machine, whereby the energy of ordinary motors, such as steam-engines, is converted into electrical energy, competent to deposit metals, to (as has already been said) fuse them, to light not only isolated buildings but extensive areas of towns and cities, and to transmit power to a distance, whether for manufacturing purposes or for the railway or tramcar; and thus the miracle is performed of converting a waterfall into a source of light, as at Sir William Armstrong's house, or into the origin of power for a railway, as at the Giant's Causeway. To the application of electrical science is due the self-exciting of the dynamos and the construction of secondary batteries, enabling a development of electricity to be continued for many hours. In the United Kingdom general electric lighting, that is to say, the lighting of large sections of a town from a central station, has been stopped by the most unwise, because most unjust, conditions imposed by the Government General Electric Lighting Act of 1882. A new and meritorious industry, which should have been granted the same privileges as are accorded to other industrial undertakings needing Parliamentary powers, was subjected to this most unjust condition: that at the end of twenty-one years the public authority of the town or place lighted should have the option of buying the undertaking for the then value of the mere materials, and that, if the authority did not choose to purchase (for it was not bound to buy), at every subsequent five-year period this option should re-arise; that is to say, that a new undertaking, which would require years for its general acceptance (for the public is slow to take up a novelty), was, after the experimental and non-paying stage had been passed, to be practically forthwith taken away for a mere fraction of the capital that had been outlaid if the undertaking paid, but was not to be taken away if it did not pay. Such, in spite of the teaching of Section F, is the condition to which our Government has arrived in respect of economic science. The next electrical matter I have to touch upon, that of the telephone and microphone, with which will for ever be associated the names of Graham-Bell, Edison, and Hughes, has, as regards the public use of the telephone, been all but similarly treated in the United Kingdom. It has been declared to be within the telegraphic monopoly given by Parliament to the Post Office nine years before the telephone was invented, and the power to use it depends entirely upon the grace and favour of the Post Office, a grace and favour not always accorded; and even when accorded, coupled with limitations as to distance, and coupled with a condition of payment of 10 per cent. of the gross receipts by the companies to the Post Office as a royalty; and all this because Government has become a trader in electrical intelligence, and fears the competition of the telephone with its telegraphs.

No one in the ship-loving countries of England, Canada, and the United States can refrain from feeling the warmest interest in all connected with navigation, and we know how frequently, alas! the prosperous voyage across the wide and fathomless ocean ends in shipwreck and disaster when the wished-for shore is approached, and when the sea is comparatively shallow. Except for the chance of collision, there is in a staunch ship little danger in the open ocean, but on nearing the shore, not only is the liability to collision increased, but shoals and sunken rocks render navigation perilous, and it is on the excellence of the lighthouses and lightships that (coupled with soundings) the sailor relies. These structures and appliances are confided to the engineer, and to be efficient they require him to be able to apply the teachings of Section A in optical science, and in the case of fogs, or as regards buoys at night-time, the science of sound. I parenthetically alluded to soundings as one (indeed a principal one) of the safeguards of ships when approaching shore. It is important in these days of high speed that these should be made with ease and without the necessity of stopping the ship, or even of diminishing its velocity. Sir William Thomson, by the application of the science of pneumatics, has enabled this to be done. Again, most important is it that the compass, amidst all the difficulties attendant upon its being situated on an iron or steel structure, should be trustworthy. And here Sir William has applied the science of magnetism in his improved compass to the practical purposes of navigation.

To go to another important branch of engineering—water-supply. The engineer dealing with a district to be fed from the surface will find himself very deficient if he have not the power of applying the science of meteorology to the work that he has in hand; he must know, not the average rainfall, for that is of but little use to him, but the maximum, and, most important of all, the minimum, rainfall over a consecutive period of years: the maximum, so that he may provide sufficient channels and by-washes for floods; the minimum, so as to provide sufficient storage. He must know what are the losses by evaporation, what are the chances of frost interfering with his filters and with his distributive plant.

Coming to the mathematical side of Section A—whether we consider the naval architect preparing his design of a vessel to cleave the waves with the least resistance at the highest speed, or whether we consider the unparalleled series of experiments of that most able Associate of Naval Architects, the late William Froude, carried out as they were by means of models which were admirable in their material, their mode of manufacture with absolute accuracy to the desired shape, and their mode of traction and of record, we must see that both architect and experimenter should be able to apply mathematical science to their work, and that it is in the highest degree desirable that they sh uld possess, as Froude did, those most excellent gifts, science and practical knowledge.

Again, the mathematical side of Section A has to be applied by engineers when considering the strength and proportion of boilers, ships, bridges, girders, viaducts, retaining walls, and in short the whole of the work with which an engineer is intrusted. Notable instances of great bridges will occur to all our minds, especially meeting as we are in this continent of grand streams, Eads' St. Louis Bridge, Roebling's Niagara Bridge, and his and and his sons' East River Bridge, Gzowski's International Bridge, and, going back to our own land, Fowler and Baker's Bridge over the Forth.

Passing from Section A to Section B, there is evidently so much overlapping of these Sections that a good deal that I have said in reference to Section A might properly have been reserved for Section B. The preparation from the ore of the various metals is in truth a branch of engineering; but to enable this to be accomplished with certainty, with economy, involving the not throwing away of that which is called the waste product but which is frequently a valuable material, it is essential that the engineer and the chemist should either be combined in one and the same person, or should go hand in hand. In the manufacture of pig iron it is absolutely necessary that the chemical constituents of the ore, the fuel, and the flux should be thoroughly understood, and that the excellence of the process followed should be tested by an analysis of the slag. For want of this chemical knowledge, thousands upon thousands of tons of bad pig iron have been made, and thousands upon thousands of tons were formerly left in the issuing slag. Similar remarks apply to the production of lead and of copper from the ores, and still more do they apply to that great metallurgical manufacture of the last few years—"steel." In the outset steel was distrusted, because of the uncertainty of its behaviour, but the application of chemical science now enables the manufacturer to produce with precision the material required to fulfil the physical tests imposed by the engineer.

Reverting to the water engineer, the chemist and the microscopist have their sciences applied to ascertain the purity of the intended source, and, as in the case of Clarke's beautiful process, by the application of chemistry, water owing its hardness to that common cause, carbonate of lime, is rendered as soft as the water from the mountain lake. Taking that other branch of engineering commonly coupled with water, viz. the supply of gas, the engineer is helpless without the application of chemistry. From the examination of the coal to be used to the testing of the gas to be supplied, there is not one stage where chemical science is not necessary. The consumer requires gas which shall be as nearly as possible a pure hydrocarbon of high illuminating power, and it might well have been that a person to whom was delivered the crude gas as it issued from the retort would have said, "Certain things may be separated out more or less, but to practise on a wholesale scale the delicate operations which will be needed to cleanse the illuminating gas from its multifarious accompanying impurities is a hopeless undertaking, and must be so, if for no other reason than this—the excessive cost that would be entailed." But what are the facts? Although I for one do not like to sit in a room where gas is burnt, unless special provision is made for taking away the products of combustion, the engineer of the present day, thanks to the application of chemical science, delivers gas to the consumer in a state of comparative purity (although it may have been made from impure coal) which but a few years ago would have been deemed impossible; and so far is this improvement from being attended with extra cost, that the residual products not now uncommonly all but pay the whole cost of the coal, and in some rare instances even leave a slight profit to go towards the charge of labour. Again, it is by the application of chemical science in the dynamite and the gun-cotton of the present day that the engineer is enabled to prepare submarine foundations, to blast away shoals, and to drive tunnels through rock of a character that cannot be dealt with by mere cutting machines. Equally to the application of chemistry is it due that there are hopes, by the employment of lime cartridges, of breaking down coal without that risk of igniting fire-damp which is attendant upon the use of gunpowder. I need hardly observe that much more might most pertinently be said on the way in which the engineer applies chemical science. In fact, those ways are so multifarious that a volume might be written upon them, but I must pass on and ask you to consider how the engineer applies geological science, the science treated by Section C.

I have already spoken of the engineer supplying towns by water collected from the surface; even he, however, must have a knowledge of geology, for without it he will not know what places are apt for the huge reservoirs he constructs, nor where he can in safety make his enormous embankments. In this continent of vast lakes one feels it must excite a sensation of the ridiculous when a "Welsh lake" is spoken of, but I must ask you to believe you are in Liliput, and to imagine that the "Bala Pond" of 1100 acres in extent, is really "Bala Lake," as it is called. Within a few miles of that, our friends at the other end of the Atlantic steam ferry, the inhabitants of Liverpool, are now constructing under the engineering and advice of Mr. Hawksley, a waterworks which will involve the formation, I believe one may say the re-formation, of a lake, practically the same area as that of Bala, of some 80 feet in depth, and containing between the overflow and the point of lowest discharge nearly twelve thousand million gallons. This lake will be made by the throwing from side to side of the valley of a solid stone bank, 100 feet above the ground, 140 feet above the deepest part of the foundations, and 113 feet thick at its thickest part. Contrasted with Lake Superior this new lake will be small, a thing demanding a microscope even, but the bursting of the wall would liberate a body of water sufficient to carry death and ruin throughout a considerable district. It is, therefore, in the highest degree important that whether he be constructing the solid stone wall, or the more common earthen embankment with a puddle trench, the engineer should so apply geological science as to insure the safety of his work. But in those cases where the waterworks engineer has to derive the supply from underground sources, the application of this science is still more necessary; he must know whether he is likely to find a water-bearing stratification at all—if so, where it receives the rain from heaven, and the extent of the area which receives it; in what direction the water travels through it, what is the varying height of water in the different parts of the stratification giving the "head" to produce that travel; how far this height is likely to be affected by the pumping of the desired quantity; whether, if near the outflow into the sea, the pumping is likely to reverse the direction of the current, and to bring back brackish water, and whether the rocks are of such a character as to be liable to yield a water impregnated with iron or with lime, and whether these water-bearing rocks are accessible from the surface without the execution of costly and laborious work in passing through overlying stratifications of an unfit or it may be even of a dangerous character. It need hardly be said that the engineer when engaged in metalliferous mining, or in the extraction of coal or of petroleum, unless he applies the science of Section C, is but a haphazard explorer whose work is more likely to end in disaster than in success. Again, the engineer, when laying out a railway, has to consider the geological features of the country in determining the angles of his cuttings, and to determine where it becomes more economical to tunnel than to cut. Indeed, without the application of that science to engineering there are some enterprises on the feasibility of which the engineer would not be able to pronounce an opinion—a notable instance, the Channel Tunnel. The engineers, of whom I am one, said there is a material, the compact non-water-bearing grey chalk, which we have at a convenient depth on the English side and, is of all materials the most suitable; if that exist the whole way across, success is certain. Then came geological science, and that told the engineer that in France the same material existed; that it existed in the same position in relation to other stratifications as it existed in England; that the line of outcrop of the gault lying below it had been checked across; and that taken together these indications enabled a confident opinion to be expressed that it was all but certain this grey chalk stratification did prevail from side to side. The engineers believed it, an intelligent section of the public believed it, and came forward with their money; large sums were expended in England and in France on the faith of the repeated declaration of the English Government (of both sides of politics), that so long as the nation was not called on to contribute towards the cost of the work, it would hail with satisfaction the improved means of communication between England and the Continent; the experimental works were carried on from both sides with the happiest results, and then, when success appeared certain, the whole work was stopped by the incredible suggestion that in the event of a war the soldiers of England, and the science of England, could not defend a couple of rat-holes, holes 14 feet in diameter and 20 miles long, situated far below the surface of the sea, having a rapid dip from the shore to a low point, gradually rising from there to the centre of the length of the tunnel, so that the English end could be flooded with sea-water in twenty-five minutes up to the soffit of the arch at the dip; and in consequence of this incredible and much-to-be-ashamed-of scare it is due that one of the finest instances of civil engineering work in connection with the science of geology, and as I believe one of the most useful works that has ever been proposed, has been put a stop to.

To come to Section D, the botanical side of it is interesting to the engineer as instructing him in the locality and quality of the various woods that he occasionally uses in his work. With regard to that most important part of the work of D, which relates to "germs" and their influence upon health, the engineer deals with it thus far: he bears in mind that the water-supply must be pure, and that the building must be ventilated, and that excreta must be removed without causing contamination; thus the waterworks engineer, the warming and ventilating engineer, and the sewage engineer can (and do) all of them profit by the labours of Section D, and can by their works assist in giving practical value to the pure science of that section.

Section E, *Geography*. Probably in these days, when our kingdom at home and the old countries near us are all but full of the works of the engineer, there are few who take a greater interest in geography than he does, and I am quite sure there are none who make a more useful application of geographical knowledge for the benefit of mankind at large than does the engineer. Almost at the outset of this address I claimed to magnify Section G, on the ground that without the aid of its members we should not have had that practical lesson in geography which we have received by our visit here, a lesson that no doubt will be continued and amplified by many of us before we return to our homes. Whether it be by the ocean steamer or by the railway train, the enterprising geographical explorer is carried to or through countries which now, thanks to the engineer, are well known and settled, up to the beginning of the unknown and not settled; and thus his labours are lightened, he consumes his energies only upon his true work, brings back his report, which is, as I have said, studied by the engineer with a view to still further development, and thus, turn by turn, the geographer and the engineer carry civilisation over the face of the world.

Now to come to Section F, which treats of Economic Science. The matters with which this Section deals—birth-rate, death-rate, the increase or the diminution of populations, the development of particular industries in different localities, the varying rates of wages, the extent and nature of taxation, the cost of production, the cost of transport, the statistics of railway and of marine disasters, the consumption of fuel, and many matters which come within the purview of F, are of importance to the engineer. Guided by the information given him by the labours of this Section, he comes to the conclusion that a work having a particular object in view should or should not be undertaken. With the information derived from the past he judges of the future; he sees what provision should be made for prospective increase of population or of industries; he sees the chances of the commercial success of an undertaking or of its failure, and he advises accordingly.

I do not propose to say anything about Section H, for I have dealt with it as being still included within D.

I trust I have now established the proposition with which I set out, viz. that not only is Section G the Section of Mechanical Science, but it is emphatically the Section of all others that applies in engineering to the uses of man the several sciences appertaining to the other Sections: an application most important in the progress of the world, and an application not to be lightly regarded, even by the strictest votaries of pure science, for it would be vain to hope that pure science would continue to be pursued if from time to time its discoveries were not brought into practical use.

Under ordinary circumstances I should have closed my address at this point, but there is a subject which at this, the first meeting of Section G after the meeting at Southport, must be touched upon. It is one of so sad a character that I have avoided all allusion to it until this the very last moment, but now I am compelled to grapple with it.

In the course of this address I have had occasion to mention several names of eminent men, many of them happily still with us, some of them passed away; but I doubt not you have been struck by the absence of one name, which of all others demands mention when considering physical science, and still more does it come vividly before us when considering the application of science to industrial purposes. I am sure I need not tell you that this name, which I can hardly trust myself to speak, is that of our dear friend William Siemens, whose contributions to science, and whose ability in the application of science, have for years enriched the transactions of this Section, and of Sections A and B, for in him were combined the mechanic, the physicist, and the chemist.

But a brief year has elapsed since he quitted the Presidential chair of the Association, and, with us at Southport, was taking his accustomed part in the work of this and of other Sections, apparently in good health, and with a reasonable prospect of being further useful to science for many valuable years to come. But it was not to be; he is lost to us, and in losing him we are deprived of a man whose electrical work has been second to none, whose thermic work has been second to none, and whose enlarged views justified him in embarking in scientific speculations of the grandest and most profound character. Whether or not his theory of the conservation of the energy of the sun shall prove to be correct, it cannot be denied that it was a bold and original conception, and one thoroughly well reasoned out from first to last.

I feel that, were I to attempt anything like the barest summary of his discoveries and inventions, I should set myself a task which could not have been fulfilled had I devoted the whole of the time I had at my command to the purpose. I had indeed thought of making his work the subject of my address, but I felt that his loss was so recent that I could not trust myself to attempt it. There is no need for me to dwell further upon this most painful topic. He was known to you all, he was honoured and loved by you all, and by every member of this Association he had so faithfully served, and over which he had so ably presided; and he enjoyed the respect and esteem of the best intelligence of England, the land of his adoption; of the Continent, his birthplace; and of Canada, and of the United States, whose populations are always ready to appreciate scientific talent and the resulting industrial progress. It is not too much to say that few more gifted men have ever lived, and that with all his ability and talent he combined a simplicity, a modesty, and an affectionate disposition that endeared him to all.

I am sorry to conclude my address to you in this mournful strain. I have endeavoured to confine my allusions to our dear friend within the narrowest limits, but if I have overstepped these I trust you will forgive me, remembering that "out of the fulness of the heart the mouth speaketh."

NOTES

WE announce with great regret the death, yesterday, at the age of eighty-three years, of Mr. George Bentham, F.R.S., F.L.S., the eminent botanist.

THE Committee which has been formed for the erection of a statue to the late Jean Baptiste Dumas at his native town, Alais (Gard), is an extensive one. The president is M. Pasteur, and the vice-presidents MM. J. Bertrand, F. de Lesseps, and Cauvet. The members of the Committee include all the names of scientific note in France. Among the foreign members are well-known men of all nationalities; the English members being Sir William Thomson, Dr. W. De La Rue, Prof. Williamson, and Dr. Frankland. There is besides a local Committee at Alais. With such powerful and wide support the monument is sure to be worthy of Dumas' reputation. Subscriptions should be sent to M. E. Maindrin, Palais de l'Institut de France, Paris.

THE National Electrical Conference, convened by the U.S. Congress in connection with the Electrical Exhibition, began its sessions in Philadelphia on Monday. Addresses were made by the President of the Conference, Prof. Rowland of the Johns Hopkins University, Baltimore; also by Sir William Thomson, the Vice-President. The practical work of the Conference began on Tuesday afternoon with a discussion on the work of the United States Signal Office in relation to electrical observation. The Conference will hereafter discuss the necessity for a national bureau of electrical standards, the adoption of an international system of electrical units, and the theory of dynamo-electric machines. Prof. George Forbes of London delivered a lecture on dynamo-electric machinery on Tuesday evening.

THE Iron and Steel Institute holds its annual meeting this year at Chester on September 23 and three following days. Among the papers and subjects for discussion are the following: —On the geology of Cheshire, by Mr. Aubrey Strahan, of H.M. Geological Survey, London; on improvements in the Siemens regenerative gas furnace, by Mr. Frederick Siemens, C.E., London; on recent improvements in the method of the manufacture of open-hearth steel, by Mr. James Riley, Glasgow, Member of Council; on a new form of regenerative furnace, by Mr. F. W. Dick, Glasgow; on the manufacture of crucible steel, by Mr. Henry Seebohm, Sheffield; on the recovery of by-products from coal, more especially in connection with the coking and iron industries, by Mr. Watson Smith, Owens College, Manchester; on the most recent results obtained in Germany in utilising the by-products from Otto and other coke ovens, by Dr. C. Otto, Dalhausen; on the North-Eastern Steel Company's Works at Middlesbrough, and their products, by Mr. Arthur Cooper, Middlesbrough; on the spectroscopic examination of the vapours evolved on heating iron, &c., at atmospheric pressure, by Mr. John Parry, Ebbw Vale.

THE museum recently opened at Newcastle-on-Tyne by the Prince of Wales is a very fine building indeed, and of course is quite unconnected with the public library. The building contains the collections of the well-known Natural History Society of Northumberland, Durham, and Newcastle-on-Tyne, and will cost 42,000*l*. Of this 38,000*l*. have been raised by public subscription.

THE preliminary programme of the Central Institution for Technical Education has been issued. The object of the Central Institution, it states, is to give to London a College for the higher technical education, in which advanced instruction shall be provided in those kinds of knowledge which bear upon the different branches of industry, whether manufactures or arts. The Institution is intended to afford practical scientific and artistic instruction which shall qualify persons to become (1) technical teachers; (2) mechanical, civil, electrical, chemical, and sanitary engineers, architects, builders, and decorative artists; (3) principals, superintendents, and managers of manufacturing works. The main purpose of the instruction to be given in this Institution will be to point out the application of different branches of science to various manufacturing industries; and in this respect the teaching will differ from that given in the Universities and in other institutions in which science is taught rather for its own sake than with the view to its industrial application. The courses of instruction will be arranged to suit the requirements of (1) persons who are training to become technical teachers; (2) persons who are preparing to enter some industrial or professional career; (3) persons who desire to attend special courses, with the view of acquainting themselves with the scientific principles underlying their work. Students intending to go through the complete course of technical instruction with the view of subse-