OUR ASTRONOMICAL COLUMN

Photographic Determinations of Stellar Positions.—Dr. B. A. Gould, in a paper presented at the Buffalo meeting of the American Association for the Advancement of Science on August 20, 1886, gives some interesting particulars with regard to his photographic work at Cordova. He states that no northern stars were photographed there except the Pleiades and the Præsepe. On the Pleiades plates all but one of Bessel's stars are found, which fall within the limits of the field; the missing one being of the magnitude 9½, whilst there are depicted on the plates other stars of the magnitudes 10, 10½, and 11. About seventy southern clusters have been repeatedly photographed at Cordova, also more than a hundred double stars, whilst the total number of photographs which Dr. Gould has on hand for measurement is about 1300, only a few having been preserved in which the images are not circular. In addition to these classes of objects, special attention was given for many years to taking frequent impressions, at the proper seasons, of four stars selected, on account of their large proper motions, as likely to manifest appreciable annual parallax. All but one of these four stars—β Hydri—have been included in the lists observed and discussed by Drs. Gill and Elkin at the Cape. Still, it will be a matter of much interest to apply the photographic method of investigation to the same problem, even if for no other purpose than a comparison of the results of the two methods. With regard to the progress made in the measurement of the Cordova photographs, Dr. Gould states that the measurements thus far completed are those of the double stars, the four stars with large proper motion, the Pleiades, the Præsepe, and the clusters Lacaille 4375 and κ Crucis. The corresponding computations have been made as yet only for a portion of the Pleiades plates, but it is expected that all these will be completed at a comparatively early date. The results deduced from the Pleiades photographs will be looked for with much interest, especially as Dr. Elkin has recently executed at Yale College a heliometric triangulation of the principal stars of the group, and the comparison of the results will be a severe test of the photographic method for the determination of stellar positions. But astronomers expect good work from Dr. Gould, and they are not likely to be disappointed. Dr. Gould's paper is published in the *Scientific American Supplement*, No. 556.

Gore's Nova Orionis.—Rev. T. E. Espin announces in *Circular* No. 9 of the Liverpool Astronomical Society that, observing on the night of September 14, he found the *Nova* to have a magnitude of 9·2. The star, he says, appeared very red. The small comes *f* was estimated as of 9·7 magnitude.

Heliometric Observations of the Pleiades.—We learn from *Science*, vol. viii. No. 187, that at the recent meeting of the American Association Dr. Elkin communicated a paper upon a comparison of the places of the Pleiades as determined by the Königsberg and Yale College heliometers. The results given were provisional, but they show unquestioned change of position with reference to η Tauri since 1860. Most of the brighter stars of the group, as shown by Newcomb in his "Catalogue of Standard Stars," go with η Tauri, but among the smaller stars there are unquestioned departures from this community of proper motion.

Gould's "Astronomical Journal."—Our readers will be glad to learn that there is a prospect of the publication of this valuable periodical being resumed. The American Association at the recent meeting passed a unanimous resolution congratulating Dr. Gould on the proposed revival of the *Journal*, and expressing its best wishes for his success.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1886 SEPTEMBER 26—OCTOBER 2

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

At Greenwich on September 26

Sun rises, 5h. 54m.; souths, 11h. 51m. 17·4s.; sets, 17h. 48m.; decl. on meridian, 1° 19′ S.: Sidereal Time at Sunset, 18h. 10m.

Moon (New on September 27) rises, 3h. 42m.; souths, 10h. 37m.; sets, 17h. 19m.; decl. on meridian, 7° 12′ N.

Planet	Rises h. m.	Souths h. m.	Sets h. m.	Decl. on meridian ° ′
Mercury	5 42	11 49	17 56	0 34 N.
Venus	4 12	10 50	17 28	6 44 N.
Mars	10 45	15 3	19 21	19 32 S.
Jupiter	6 49	12 30	18 12	4 18 S.
Saturn	23 8*	7 11	15 14	21 28 N.

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

Sept.	h.	
26	17	Venus in conjunction with and 0° 34′ north of the Moon.
28	3	Mercury in superior conjunction with the Sun.

Variable Stars

Star	R.A. h. m.	Decl. ° ′		h. m.	
Algol	3 0·8	40 31 N.	Sept. 29,	3 43	*m*
			Oct. 2,	0 31	*m*
λ Tauri	3 54·4	12 10 N.	,, 2,	5 16	*m*
ζ Geminorum	6 57·4	20 44 N.	Sept. 29,	2 48	*m*
T Geminorum	7 42·5	24 1 N.	Oct. 1,		*M*
δ Libræ	14 54·9	8 4 S.	Sept. 28,	1 45	*m*
U Coronæ	15 13·6	32 4 N.	,, 28,	23 27	*m*
U Ophiuchi	17 10·8	1 20 N.	,, 28,	1 20	*m*
				21 28	*m*
W Sagittarii	17 57·8	29 35 S.	,, 28,	0 0	*M*
U Sagittarii	18 25·2	19 12 S.	,, 28,	6 0	*m*
			Oct. 1,	6 0	*M*
R Lyræ	18 51·9	43 48 N.	Sept. 28,		*m*
S Vulpeculæ	19 43·7	27 0 N.	,, 29,		*m*
δ Cephei	22 24·9	57 50 N.	Oct. 2,		*m*

M signifies maximum; *m* minimum.

Meteor Showers

The *Aurigids*, R.A. 85°, Decl. 50° N., the *Aquarids*, R.A. 33°, Decl. 2° S., and meteors from the following radiants have been observed at this time:—From Musca, R.A. 46°, Decl. 26° N.; near ι Aurigæ, R.A. 70°, Decl. 32° N.; and near α Cephei, R.A. 315°, Decl. 62° N.

Stars with Remarkable Spectra

Name of Star	R.A. 1886·0 h. m. s.	Decl. 1886·0 ° ′	Type of spectrum
T Arietis	2 41 57	17 1·9 N.	III
D.M. + 8° 443	2 47 38	8 52·1 N.	III.
ρ Arietis	2 49 23	17 52·1 N.	III.
α Ceti	2 56 18	3 38·5 N.	III.
ρ Persei	2 57 50	38 23·9 N.	III.
D.M. + 57° 702	3 2 40	57 28·2 N.	IV.

THE BRITISH ASSOCIATION

SECTION G

MECHANICAL SCIENCE

Opening Address by Sir James N. Douglass, M.Inst.C.E., President of the Section

. . . I propose to address you on a subject with which I have been practically connected for nearly half a century, that is, the development of lighthouses, light-vessels, buoys, and beacons, together with their mechanical and optical apparatus. . . .

During the last century a very considerable increase has occurred in the number of lighthouses and light-vessels on the various coasts of the world, which have been required to meet the rapid growth of commerce. Only during the last twenty-five years can accurate statistical information be obtained, and it is found that in the year 1860 the total number of coast lights throughout the world did not exceed 1800, whereas the present number is not much less than 4000. . . .

Concurrently with the enormous increase in the number of coast lights during the last fifty years, very great improvements have been effected from time to time in their efficiency. In 1759 Smeaton's lighthouse on the Eddystone was illuminated by 24 tallow candles, weighing ⅖ lb. each. The intensity of the light of each candle, I find, from experiments made with similar candles prepared for the purpose, to have been about 2·8 candle units each; thus the aggregate intensity of radiant light from the 24 candles was only about 67 candle units. No optical apparatus, moreover, was used for condensing the radiant light of the candles, and directing it to the surface of the sea. The consumption of tallow was about 3·4 lbs. per hour; therefore, the cost of the light per hour, at the current price of tallow candles, would be about 1*s*. 6¾*d*., sufficient to provide a mineral oil light, at the focus of a modern optical apparatus, to produce for the service of the mariner a beam of about 2400 times the above-mentioned intensity.

The introduction of catoptric apparatus for lighthouse illumination appears to have been first made at Liverpool, about 1763, and was the suggestion of William Hutchinson, a master mariner of that port. The invention by Argand, in 1782, of the cylindrical wick lamp, provided a more efficient focal luminary than the flat wick lamp previously employed, and was soon generally adopted, for both fixed and revolving lights. In 1825 the French lighthouse authorities effected another very important improvement in lighthouse illumination by the introduction of the dioptric system of Fresnel in conjunction with the improvements of Arago and Fresnel on the Argand lamp, by the addition of a second, third, and fourth concentric wick.

Coal and wood fires, followed by tallow candles and oil, have been referred to as the early lighthouse illuminants. In 1827 coal gas was introduced at the Troon Lighthouse, Ayrshire, and in 1847 at the Hartlepool Lighthouse, Durham, the latter for the first time in combination with a first-order Fresnel apparatus. The slow progress made with coal gas in lighthouses, except for small harbour lights, where the gas could be obtained in their vicinity, was chiefly due to the great cost incurred in the manufacture of so small a quantity as that required and at an isolated station. In 1839 experiments were made at the Orford Low Lighthouse, Suffolk, with the Bude light of the late Mr. Goldsworthy Gurney. This light was produced by throwing oxygen gas into the middle of a flame derived from the combustion of fatty oils. The flame was of the dimensions of that of the Fresnel four-wick concentric burner. An increased intensity over that of the flame of the large oil burner was obtained, but it was not found to be sufficient to justify the increased cost incurred. In 1857 a trial was made by the Trinity House, at Blackwall, under the advice of Faraday, with one of Holmes's direct current magneto-electric machines for producing the electric arc light for a lighthouse luminary, and the experiment was found to be so full of promise for the future that a practical trial was made during the following year.

At the South Foreland High Lighthouse, on December 8, 1858, the first important application of the electric arc light, as a rival to oil and gas for coast lighting, was made with a pair of Holmes's machines, and thus were steel magnets made to serve not only, as in the mariner's compass, to guide him on his path, but also to warn him of danger. In 1859 the experimental trials at the South Foreland were discontinued, but they were sufficiently encouraging to lead to the permanent installation of the electric light at Dungeness Lighthouse in 1862. In 1863 the electric arc light was adopted by the French lighthouse authorities at Cape La Hève.

In 1871, after practical trials with a new alternating current machine of Holmes, two of such machines were supplied to a new lighthouse on Souter Point, coast of Durham, and in the following year the electric arc light, with these machines, was established in both the High and Low Lighthouses at the South Foreland, where it still shines successfully. The early experience with the electric light at Dungeness was far from encouraging. Frequent extinctions of the light occurred from various causes connected with the machinery and apparatus, and the oil light had, at such times, to be substituted. As no advantage can counterbalance the want of certainty in signals for the guidance of the mariner, no further step in the development of the electric light was taken by the Trinity House until the latter part of 1866, when favourable reports were received from the French lighthouse authorities of the working of the Alliance Company's system at the two lighthouses of Cape La Hève. Complaints were also received from mariners, in the locality of Dungeness, of the dazzling effect on the eyes when navigating, as they are there frequently required to do, close inshore, thus being prevented from rightly judging their distance from this low and dangerous point. Therefore, in 1874, the electric light was removed from Dungeness, and a powerful oil light substituted. In 1877 the electric arc light was installed at the Lizard Lighthouses on the south coast of Cornwall, and arrangements are now being made for establishing it at St. Catherine's Lighthouse, Isle of Wight, and at the High Tower, on the Isle of May, Firth of Forth. I have mentioned that the first machines of Holmes at the South Foreland were direct current, the machines provided by him for Dungeness being also of the same type. The French lighthouse authorities, however, adopted for their lighthouses at Cape La Hève the "Alliance" alternating current magneto-electric machines, and, in consequence of the less wear and tear of these machines with greater reliability through their having no commutator, Holmes was required to supply alternating current machines for Souter Point and the South Foreland. Those machines have been running at these stations fourteen years and fifteen years respectively. They have during this period required only a very trifling amount of repair, and are still in excellent order, but the time must soon arrive for replacing them by more powerful machines.

In 1876 a series of trials was made by the Trinity House at the South Foreland, with various dynamo-electric machines, for the purpose of ascertaining the then most suitable machine for adoption at the Lizard. The results were decidedly in favour of the Siemens direct current machine, and machines of this type were accordingly installed at the Lizard Station in 1878. In consequence of irregularities in their working, and because, at the time, Baron de Méritens, of Paris, had perfected a very powerful alternating current machine, it was resolved to send one of the latter machines to the Lizard for trial, where it has worked most satisfactorily for several years. The experience gained at the Lizard suggested that, for the St. Catherine's Station, where it had been resolved to adopt the electric arc light, the De Méritens machines should be employed, and they were accordingly ordered; but, as arrangements were then being made for experiments at the South Foreland for testing the relative merits of electricity, gas, and oil as lighthouse illuminants, it was determined that these machines should first be sent there for the experiments. In 1862 a practical trial was made by the Trinity House at the South Foreland of the Drummond or lime light, but the results were not so satisfactory, after experience with the electric arc light, as to encourage its adoption. In the meantime the successful development of the electric arc light for lighthouse illumination very soon acted as a keen stimulus to inventors of burners for producing gas and oil luminaries for the purpose; in 1865 the attention of lighthouse authorities was directed to the gas system of Mr. John R. Wigham, of Dublin, which system was tried in that year by the Commissioners of Irish Lights at the Howth Bailey Lighthouse, near Dublin, and in 1878 he introduced at the Galley Head Lighthouse, county Cork, his system of superposed gas burners. At this lighthouse four of his large gas burners and four tiers of first-order annular lenses, eight in each tier, were adopted. By successive lowering and raising of the gas flame at the focus of each tier of lenses, he had previously produced the first group flashing distinction. This light shows, at periods of one minute, from ordinary annular lenses, instead of the usual long flash, a group of short flashes, varying in number between six and seven. The uncertainty, however, in the number of flashes contained in each group is found to be an objection to the optical arrangement here adopted. In the meantime the attention of the Trinity House, the Commissioners of Northern Lights, and the French lighthouse authorities was being directed to the question of substituting mineral oil for colza as a lighthouse illuminant. In 1861 experiments were made by the Trinity House for the purpose of determining the efficiency and economy of mineral oils in relation to colza for lighthouse illumination; but, owing to the imperfectly-refined oil then obtainable and its high price, the results were not found to be quite so satisfactory as to justify a change from colza oil, at that time generally used. In 1869 the price of mineral oil, of good illuminating quality and safe flashing-point, having been reduced to about one-half the price of colza, the Trinity House determined to make a further series of experiments, when it was ascertained that, with a few simple modifications, the existing burners were rendered very efficient for the purpose, and a change from colza to mineral oil was commenced. It was found, during these experiments, that the improved combustion effected in the colza burners, in their adaptation for consuming mineral oils, had the effect of increasing their mean efficiency, when burning colza, 45¾ per cent. A further advance was made during these experiments by increasing the number of wicks of the first-order burner from four to six, more than doubling the intensity of the light, while effecting an improved compactness of the luminary per unit of focal area of 70 per cent.

With coal fires no distinctive characters were possible beyond the costly ones of double or triple lighthouses. There are at present not less than 86 distinctive characters in use throughout the lighthouses and light-vessels of the world; and, as their numbers increase, so does the necessity for giving a more clearly distinctive character to each light over certain definite ranges of coast. This important question of affording to each light complete distinctive individuality is receiving the attention of lighthouse authorities at home and abroad, and it is hoped that greater uniformity and consequent benefit to the mariner will be the result.

During the old days of sailing-vessels, when the duration of voyages was so uncertain, sound-signals, as aids to the mariner, were but little demanded. The seaman on approaching the coast in fog trusted entirely to his lead, and, when he found circumstances favourable for doing so, he anchored his vessel until the atmosphere cleared. But, since the application of steam to navigation, with keener competition in trade, these conditions have been entirely changed. The modern steam-vessel is expected to keep time with nearly the same degree of precision as a railway train, and it is evident that, even with the utmost care and attention on the part of her commander, this requirement cannot possibly be fulfilled, and collisions and strandings must occur, unless efficient sound-signals for fog be carried by each vessel, and powerful signals of this class be provided at lighthouse and light-vessel stations.

These circumstances have led to a rapid development of fog-signals, both ashore and afloat, there being now about 700 of these signals, of various descriptions, on the coasts of the world. We therefore find, as might have been naturally expected, that coast fog-signals have been made, by lighthouse authorities, the subject of careful experiment and scientific research; but, unfortunately, the practical results thus far have not been so satisfactory as could be desired, owing (1) to the very short range of the most powerful of these signals under occasional unfavourable conditions of the atmosphere during fog; and (2) to the present want of a reliable test for enabling the mariner to determine at any time how far the atmospheric conditions are against him in listening for the anxiously expected signal. In 1854 some experiments on different means of producing sounds for coast fog-signals were made by the engineers of the French lighthouse department, and in 1861-62 MM. Le Gros and Saint-Ange Allard, of the Corps des Ponts et Chausées, conducted a series of experiments upon the sound of bells and the various methods of striking them.

In 1863-64 a Committee of the Elder Brethren of the Trinity House made some experiments at Dungeness upon various fog-signals. In June 1863 a Committee of the British Association memorialised the then President of the Board of Trade, with the view of inducing him to institute a series of experiments upon fog-signals. The memorial, after briefly setting forth a statement of the nature and importance of the subject, described what was then known respecting it, and several suggestions were made as to the nature of the experiments recommended. The proposal does not appear to have been favourably entertained by the authorities to whom it was referred, and the experiments were not carried out.

In 1864 a series of experiments was undertaken by a Commission appointed by the Lighthouse Board of the United States, to determine the relative powers of various fog-signals which were brought to the notice of the Board.

In 1872 a Committee of the Trinity House visited the United States and Canada, with the object of ascertaining the actual efficiency of various fog-signals then in operation on the North American continent, about which very favourable reports had reached this country. Among other instruments, they witnessed the performance of a Siren apparatus, patented by Messrs. A. and F. Brown, of New York. One of these instruments was, in 1873, very kindly sent to the Trinity House by the United States authorities, and tested with other instruments in the experimental trials at the South Foreland in 1873-74. This investigation was carried out at the South Foreland by the Trinity House, with the object of obtaining some definite knowledge as to the relative merits of different sound-producing instruments, and also of ascertaining how the propagation of sound was affected by meteorological phenomena. These experiments were extended over a lengthened period, in all conditions of weather; and the well-known scientific and practical results obtained, together with the ascertained relative merits of sound-producing instruments for the service of the mariner, are of the highest scientific interest and practical importance.

The investigation at the South Foreland was followed up by the Trinity House by further experiments, in which they were assisted by the authorities at Woolwich, with guns of various forms, weight of charges, and descriptions of gunpowder. The powders tested were (1) fine grain, (2) larger grain, (3) rifle large grain, and (4) pebble. The result placed the powders exactly in the order above stated; the fine grain, or most rapidly burning powder, gave indisputably the loudest sound, while the report of the slowly-burning pebble powder was the weakest of them all. Experiments were also made with the object of ascertaining the relative value of the sound produced by the explosion of varying quantities of gun-cotton. Here again the greater value of increased rapidity of combustion in producing sound was clearly demonstrated. It was found that charges of gun-cotton yielded reports louder at all ranges than equal charges of gunpowder, and further experiments proved that the explosion of half a pound of gun-cotton gave a result at least equal to that produced by 3 lb. of the best gunpowder. These results led the Trinity House to adopt this explosive as a fog-signal for isolated stations on rocks or shoals where previously, from want of space, nothing better than a bell could be applied. It is also applied with success to light-vessels. But, wherever the Siren can be installed, it is found to be the most efficient fog-signal yet known, chiefly in consequence of the prolongation that can be given to its blasts, and the ease with which it can be applied, with any amount of motive-power available, to the production of any desired combination of high and low notes for distinctions corresponding with those of white and red, or short and long, flashes of light, and thus affording the required individuality of each station. The experience, however, with the most powerful fog-signal is not at present to be considered altogether satisfactory. With Siren blasts absorbing about 150 H.P., or nearly 5,000,000 foot-pounds, per minute during the time they are sounding, the signal is occasionally not heard, under some conditions of fog and wind, beyond 1 mile, while at other times it is distinctly heard above 10 miles. . . .

In 1881 it was considered by the lighthouse authorities of this country that the time had arrived when it was absolutely necessary that an exhaustive series of experimental trials should be made, on a practical scale, for the exact determination of the relative merits (both as regards efficiency and economy) of the three lighthouse illuminants, electricity, gas, and mineral oil, which, by the process of natural selection, may be regarded as the fittest of all those at present known to science. After many unforeseen difficulties had been overcome, this question of universal importance was, in July 1883, referred by the Board of Trade to the Trinity House, who accepted the responsibility of carrying out the investigation.

A Committee was formed of members of the Corporation, who secured the friendly co-operation of the Scotch and Irish Lighthouse Boards, and many distinguished scientific men at home and abroad. I had the honour of acting, in my official capacity as Engineer-in-Chief to the Trinity House, in making the arrangements for exhibiting the experimental lights, and in reporting to the Board from time to time, as in all other matters referred to me professionally.

These investigations were carried out in full view of all who were in any way interested in the subject. The whole arrangements were open to public inspection, and, in their desire to arrive at a wise and just decision on so important a question, the Trinity House Committee courted the fullest inquiry. Many members of scientific Societies, especially those connected with engineering, were invited, and visited the station. The French lighthouse authorities, who rendered much kind assistance in obtaining observations, sent their representatives to view the arrangements, and officers from the lighthouse services of Germany, Denmark, Norway and Sweden, Russia, Italy, Spain, Brazil, the United States, and Canada visited the station and witnessed the experiments.

In order to obtain, with uniformity and method, a consensus of comparative eye-measurements—in addition to the measurements of the Committee and their officers at their different stations ashore and afloat, to those of the coastguard men at nine stations between Dungeness and the North Foreland, and to the more precise scientific measurements of the experts—special observation-books were prepared, and widely distributed to shipping associations and port authorities, with a view to their securing the co-operation of masters of vessels, pilots, and others navigating in the vicinity of the South Foreland.

The South Foreland Station is especially adapted for lighthouse experiments generally, because of the existing facilities for observations on land and sea. The land in the neighbourhood has no hedges and few trees, and affords facilities for observations at distances of between 2 and 3 miles. The station is provided with surplus steam power for driving experimental machines for electric lights, and it is easily accessible from London.

Three rough timber towers of sufficient strength to withstand, without tremor, the effects of heavy gales were erected at the rear of the High Lighthouse, 150 feet apart. These towers were marked in large letters, A, B, and C. A tower was devoted to electricity, B to the gas system of Mr. Wigham, and C to such gas or oil lamps as might be proposed to, and approved by, the Committee for trial during the experiments. A lantern of the usual first-order dimensions, but with an additional height in the glazing for the passage of beams from superposed optical apparatus of the first order, was provided for each tower. The optical apparatus in each lantern was, in the outset, special in relation to the illuminant to be used for producing fixed and flashing lights. For the electric arc lights, optical apparatus of the second order of Fresnel was adopted, the apparatus having a focal distance of 700 mm. The dimensions of this apparatus are greater than optically required for the largest electric arc light yet tried for lighthouse illumination, but the internal capacity is found to be only just sufficient for the perfect manipulation of the light by a light-keeper of possibly robust build. For the large gas and oil flames in the A and C lanterns the apparatus adopted was of the usual first-order size, having a focal distance of 920 mm.

The lanterns were partially glazed on opposite sides, north and south, the southern arc being chiefly for observation from the sea. To the northward the land is better adapted for observations on shore, and here three observing-huts were erected at the respective distances of 2144, 6200, and 12,973 feet; each hut was provided with accommodation for two watchers, and a chamber fitted with a large plate-glass window in the direction of the experimental lights, and special apparatus for their photometric measurement. The third hut proved to be practically of but little value for photometry, the distance being too great; it, however, afforded an accurately known distance for eye-measurements, and a barrack and starting-point for watchers endeavouring to determine the vanishing distance of each light during hazy weather. In this they were further assisted by white painted posts, placed throughout the whole track to the experimental lighthouses, at distances of 100 feet apart, the distance of each post from the lights being plainly marked on it in black figures. For the more exact examination and measurements of the intensity of each luminary and that of the beam from each optical apparatus, a photometric gallery was erected in a convenient position, 380 feet long by 8 feet wide, and provided with all the necessary appliances.

During a period of over twelve months the experimental lights were exhibited, and watched by numerous observers, trained and untrained, scientific and practical. During that period a vast amount of valuable evidence was collected, by the aid of which the Committee were subsequently enabled to state their conclusions with definiteness. During these investigations intensities were shown in a single oil and gas luminary about three times greater than the electric arc luminary first adopted at Dungeness in 1861, while, with a single electric arc luminary, there was shown a practically available focal intensity about fifteen times greater than that of the Dungeness luminary, and the highest yet shown to be practically available for the service of the mariner.

With gas and oil the highest intensity of a single luminary and optical apparatus was tripled by the use of three superposed luminaries and optical apparatus, and although optical arrangements were made for triple electric luminaries, and experiments were carried out with these at comparatively low intensities, it was soon found that all the electromotive force available at the station could be conveniently applied with efficiency and permanency in one compact focal luminary, and its optical apparatus. This fact demonstrated that the electric arc has the most important requisites of a lighthouse luminary; viz. maximum intensity and minimum focal dimensions, and in all states of the atmosphere, from clear weather to thick fog, an incontestable superiority over the utmost accumulative efforts of its rivals—gas and oil. It was therefore considered to be unnecessary to incur additional cost for exhibiting the electric arc light, under the same conditions of accumulative powers as its rivals, for showing a maximum intensity. With the best gas and oil luminaries it was found that, where gas of the ordinary commercial quality is employed, there is no appreciable difference, either in the intensity or focal compactness of the luminary, but when the richest gas, from cannel coal, and mineral oil are used, there is found to be a superiority in the maximum intensity of this luminary over oil of about 45 per cent., and in focal compactness of about 10 per cent.; but in haze and fog, when the maximum intensity only is required, this difference was found to effect no appreciable gain in penetrative power, therefore the question of merit between these illuminants was found to resolve itself into one of economy only, and in this respect mineral oil at the present market prices was found to have a considerable advantage.

The relative penetrability per unit of light of the best gas and oil flames in haze and fog is so nearly identical that the question is of no practical importance in lighthouse illumination. But, with regard to the relative atmospheric absorption of these lights and the electric arc light in certain impaired conditions of the atmosphere, the electric arc light is found to compare somewhat unfavourably. The general result of the photometric measurements of the three illuminants showed (1) that the oil and gas lights, when shown through similar lenses, were equally affected by atmospheric variation; (2) that the electric light is absorbed more largely by haze and fog than either the oil or the gas light; and (3) that all three are nearly equally affected by rain. Experiments made in the photometric gallery at the South Foreland with the electric arc light have shown that the loss by atmospheric absorption is by no means so great as was previously supposed. It would have been most interesting and instructive to have obtained data for exactly determining the relative coefficients of atmospheric absorption of the electric arc, gas, and oil luminaries, but the necessary observations and measurements for effecting this would have prolonged the time too much, and added too much to the cost of the investigation, especially when it is remembered that with the electric arc light there is for coast illumination such an enormous preponderance of initial intensity at disposal that a small percentage of penetrating efficiency is of no practical importance.

In 1836 Faraday showed by actual experiment that the penetrating power of a light in atmosphere impaired by such obstruction as fog, mist, &c., is but very slightly augmented by a very considerable increase in the intensity, and M. Allard, late Engineer-in-Chief to the French Lighthouse Board, has more recently shown after long experimental and practical research, that, in an atmosphere of average transparency, a beam of light equal to 6250 becs (Carcel) would penetrate 53 kilometres, yet when augmented to twenty times that intensity, or 125,000 becs (Carcel), it would only penetrate 75·40 kilometres; showing that, in the average condition of atmospheric transparency, 2000 per cent. of increased intensity only gives 42 per cent. longer range.

The South Foreland experiments have demonstrated that, while with both gas and oil an ordinary intensity of light can be adopted for clear weather sufficient to reach the sea horizon with efficiency for the mariner, a maximum light can be shown with impaired atmosphere fifteen to twenty times this intensity, and that in these respects both illuminants are practically on an equality. This maximum light of gas and oil is considered by the Committee to be sufficient for all the ordinary purposes of navigation, and, for this, mineral oil is the most economical illuminant; but for some special cases, where the utmost intensity and penetration are demanded, these results can only be attained by electricity, and by this agent an intensity more than ten times that of the maximum of either oil or gas is found to be practically available.

With regard to the gas and oil lights, the report of the Committee states that "It appears from the direct eye-observations, made at distances varying from 3 to 27 miles in clear weather, that through annular lenses, light for light, there is practically no difference. Both reach the horizon with equal effect. In weather not clear the records indicate practically the same relation. In actual fog, again, the records indicate a general equality of the lights. Both are lost at the same time, both are picked up together; and although here and there a very slight superiority is attributed to the gas, this superiority is of no value whatever for the purposes of the mariner." A point referred to in favour of gas is the well-known one of greater handiness and ease of manipulation than oil, which is of importance for small beacon lights, where a constant attendant is not provided; but this does not apply to a coast light, where a light-keeper is always required to be on the watch in the lantern from sunset to sunrise. With oil the great advantage, in addition to economy, lies in the simplicity of its application to a coast lighthouse in any part of the world, however limited the space the lighthouse is necessarily required to occupy. The final conclusion of the Committee on the relative merits of electricity, gas, and oil as lighthouse illuminants is given in the following words:—"That, for ordinary necessities of lighthouse illumination, mineral oil is the most suitable and economical illuminant, and that for salient headlands, important landfalls, and places where a very powerful light is required, electricity offers the greatest advantages."

In conclusion it may safely be asserted, now that the relative merits of electricity, gas, and oil have been accurately determined, that these investigations of the Trinity House Committee will, for many years to come, furnish to the lighthouse authorities of all maritime nations of the world, and their engineers, very valuable data which cannot fail to assist very largely in the development of lighthouse illumination, and thus tend very materially to present aids to navigation, and to a consequent reduction in the loss of life and property at sea.

REPORTS

Third Report of the Committee, consisting of Prof. Balfour Stewart (Secretary), Mr. J. Knox Laughton, Mr. G. J. Symons, Mr. R. H. Scott, and Mr. Johnstone Stoney, appointed for the Purpose of co-operating with Mr. E. J. Lowe in his Project of establishing on a Permanent and Scientific Basis a Meteorological Observatory near Chepstow.—In answer to a letter written by Prof. Balfour Stewart, pointing out certain conditions indispensable to the success of the project, Mr. Lowe writes:—"The (local) Committee think that they see their way to getting two or three thousand pounds if the scheme were started. Since you were with me I have purchased nearly 150 acres of land in front of the observatory, and nothing could come between it and the channel as near as 1½ to 2 miles. A new road is to be made to the Severn Tunnel Station, and I hear that the telegraph or telephone is likely to be carried up this road. If your Committee think well to recommend the observatory scheme, action would be at once taken, and we have reason to believe that the Bristol Docks would help us with 100*l*. a year. I should much like to see such an observatory in working order whilst I live, but my time is getting short. There is a growing interest round here about the observatory, and constant inquiries are made as to the probabilities of success." The Committee express their sympathy with Mr. Lowe and his friends under the unfortunate circumstances that have tended to retard local action. The Committee see such evidence of local interest in the undertaking that they desire to have an early opportunity of co-operating with the local Committee. They therefore ask for their re-appointment, and request that the unexpended sum of 25*l*. and an additional sum of the same amount—in all 50*l*.—be placed at their disposal for the purpose.

A Report of the Committee consisting of Profs. Tilden and Ramsay and Dr. Nicol (Secretary), appointed for the Purpose of Investigating the Subject of Vapour-Pressures and Refractive Indices of Salt Solutions, was read by Dr. Nicol.—The report deals with the general conclusions arrived at from recent experiments on vapour-pressures, rates of expansion, refractive indices, and saturation of salt solutions. The experiments on the vapour-pressure of salt solutions completely disprove the statement of Wüllner, that the diminution of vapour-pressure is directly proportional to the percentage of salt present; in some cases it has been observed that the restraining effect of each molecule increased with the concentration, whilst with other salts it decreased on the addition of salt even in dilute solutions. Such results can, however, be readily explained by the theory of solution proposed by Nicol in the *Philosophical Magazine*, 1883.

The Report of the Committee consisting of Profs. Ramsay, Tilden, W. L. Goodwin (Secretary) and D. H. Marshall, appointed for the Purpose of Investigating Certain Physical Constants of Solutions, was read by Prof. Ramsay.—This report contained an account of an investigation conducted by Profs. Goodwin and Marshall of the Queen's University, Kingston, Ontario, the object of which was the determination of the condition of equilibrium assumed by molecular weights of two salts placed in separate small vessels and inclosed with a weighed quantity of water. The process by which the water is so attracted to the salts was styled "invaporation" by Graham. The salts experimented with were the chlorides of potassium, lithium, and sodium. When sodium and potassium chlorides were used, and different quantities of water, it was found that sodium chloride invaporates the water more rapidly than potassium chloride, and that, with small relative quantities of water, the sodium chloride invaporates nearly all and leaves the potassium chloride almost dry. When this is compared with the state of equilibrium assumed by equivalents of caustic soda, caustic potash, and sulphuric acid in solution together, it seems that the force in the first case is different in character from that acting in the second. Similar experiments made with sodium and lithium chlorides, and varying the relative quantities of water, showed that with small relative quantities of water the lithium chloride attracted the whole, but with larger quantities the sodium chloride attracts part, showing that in this case there is a limit to the quantity of water which the lithium chloride can hold against the attraction of sodium chloride. When the relative quantity of water is small, it is not divided between the two salts in the ratio of their attraction for water; but this may be the case with large relative quantities of water. The process of invaporation is in all cases very slow, in some cases requiring several months for its completion. A further investigation of these phenomena with other salts, and a study of the influence of temperature is promised.

A Preliminary Report of the Committee consisting of Profs. McLeod and Ramsay, with Mr. W. A. Shenstone as Secretary, appointed for the Further Investigation of the Influence of the Silent Discharge of Electricity on Oxygen and other Gases, was read by Mr. Shenstone.—A description was given of the apparatus devised for the storage and convenient manipulation of oxygen, so as to insure its perfect purity. The use of a mixture in molecular proportions of potassium and sodium chlorates is recommended in the preparation of oxygen, inasmuch as the breakage of apparatus, when potassium chlorate alone is used, is to a great extent done away with.

The Report of the Committee consisting of Profs. W. A. Tilden and H. E. Armstrong, appointed for the Purpose of Investigating Isomeric Naphthalene Derivatives, of which Prof. H. E. Armstrong is the Secretary, was read by the latter, who pointed out that, owing to its constitution, naphthalene lends itself very easily to the production of isomeric compounds. The constitution of the disulphonic acids of naphthalene has been specially investigated, and four isomeric compounds were described, as were also several isomeric bromo-derivatives.

The Committee consisting of Prof. Sir H. E. Roscoe, Mr. Lockyer, Profs. Dewar, Liveing, Schuster, W. N. Hartley, and Wolcott Gibbs, Capt. Abney, and Dr. Marshall Watts, appointed for the Purpose of Preparing a New Series of Wave-Length Tables of the Spectra of the Elements, of which Dr. Marshall Watts is the Secretary, reported that satisfactory progress had been made during the past year with the work allotted to it, and that the forthcoming volume of the *Proceedings* of the Association will contain additions to the tables of wave-lengths of the emission spectra of the elements and compounds.

Report of a Committee, consisting of General J. T. Walker, General Sir J. H. Lefroy, Prof. Sir William Thomson, Mr. Francis Galton, Mr. Alex. Buchan, Mr. J. Y. Buchanan, Dr. John Murray, Mr. H. W. Bates, and Mr. E. G. Ravenstein (Secretary), appointed for the Purpose of taking into Consideration the Combination of the Ordnance and Admiralty Surveys, and the Production of a Bathy-hypsographical Map of the British Isles.—(1) The Committee consider that the production of a plain outline map of the British Isles and surrounding seas, on a scale of 1 : 200,000 (about three miles to the inch) would be desirable. Rivers, and such other physical features as can be shown in outline, to be marked distinctly. No hill-shading to be introduced. Roads, railways, towns, &c., to be indicated faintly, and merely for the purpose of identifying localities. Principal heights and depths above and below the datum level of the Ordnance Survey of Great Britain to be inserted. Contours to be drawn at intervals of 200 feet, with subsidiary contours where they are necessary, to give expression to the features of the ground. Incidental features, such as cliffs, &c., to be marked. The map to be tinted according to height. (2) A grant of 25*l*. to be applied for in order that a specimen sheet of the map may be prepared. (3) The Clyde Trustees to be approached, with a view to their undertaking the preparation of a similar map of the Clyde estuary on a suitably larger scale. Other harbour Boards to be similarly approached.

(4) The Committee anticipate that, being provided with maps of this character as specimens of what is required to supply a national want, the Association may be in a better position than at present to move the Government to undertake the preparation of a similar map of the whole of the United Kingdom, based mainly upon the extensive data already available in the archives of the Ordnance Survey and the Admiralty.

Report of the Committee, consisting of Dr. J. H. Gladstone (Secretary), Prof. Armstrong, Mr. William Shaen, Mr. Stephen Bourne, Miss Lydia Becker, Sir John Lubbock, Bart., Dr. H. W. Crosskey, Sir Richard Temple, Sir Henry E. Roscoe, Mr. James Heywood, and Prof. N. Story-Maskelyne, appointed for the Purpose of Continuing the Inquiries Relating to the Teaching of Science in Elementary Schools.—No steps in advance have been taken by any Government Department towards the more adequate provision for science-teaching in elementary schools during the past year. There have been four different Vice-Presidents of the Committee of Council on Education during the last twelve months; and Sir Lyon Playfair only came into office after the Code for the year had been settled. The annual return of the Education Department for England and Wales issued this year, which deals with the period from September 1, 1884, to August 31, 1885, shows that the present regulations tell unfavourably on the prospects of science. The following statistics for the last three years show that, while the preferential class subject "English" is taken in an increasing number of departments year by year, geography shows an actual falling off, and elementary science seems even to be losing the little footing it had. Needlework shows a steady increase, as it is an obligatory subject in girls' schools, and it is more advantageous in a financial point of view to take it up as a class subject rather than under Article 109 (*c*), in which case it necessarily displaces geography or science:—

Class Subjects	1882-83 Departments	1883-84 Departments	1884-85 Departments
English	18,363	19,080	19,431
Geography	12,823	12,775	12,336
Elementary Science	48	51	45
History	367	382	386
Needlework	5,286	5,929	6,499
	18,524	19,137	19,266

In regard to the scientific specific subjects, the following are the number of children individually examined:—

Specific Subjects	1882-83 Children	1883-84 Children	1884-85 Children
Algebra	26,547	24,787	25,347
Euclid and Mensuration	1,942	2,010	1,269
Mechanics, A	2,042	3,174	3,527
,, B	—	206	239
Animal Physiology	22,559	22,857	20,869
Botany	3,280	2,604	2,415
Principles of Agriculture	1,357	1,859	1,481
Chemistry	1,183	1,047	1,095
Sound, Light, and Heat	630	1,253	1,231
Magnetism and Electricity	3,643	3,244	2,864
Domestic Economy	19,582	21,458	19,437
Extra (Physiography)	—	16	—
	82,965	84,515	79,774
No of Scholars in Standards V., VI., VII.	286,355	325,205	352,860

It is evident that while the number of scholars in the higher standards has considerably increased, the number examined in specific (scientific) subjects has considerably decreased; and this decrease has occurred in every subject except mechanics. Algebra and chemistry show rather larger numbers than last year, though not in proportion to the increase of scholars. The comparative decrease in the attention paid to these scientific subjects will be evident from the percentages of children examined:—

In 1882-83	29·0 per cent.
In 1883-84	26·0 ,,
In 1884-85	22·6 ,,

but it must be borne in mind that in many schools the children take two subjects, in which case they count accordingly. Increased though still very inadequate attention seems to be paid in the training colleges to the preparation of the students in the science subjects; the number of individual students who have qualified for teaching one or more sciences has risen from 2205 in 1884 to 2407 in 1885, and it is satisfactory to note that the increase has been mainly in passes in the first class. The number of papers worked in the several subjects in the two years under review have been as follows:—

Number of papers worked	1884	1885
Pure Mathematics	82	121
Theoretical Mechanics	21	25
Sound, Light, and Heat	488	690
Magnetism and Electricity	693	551
Inorganic Chemistry	245	269
,, ,, (practical)	166	160
Animal Physiology	416	257
Botany	485	483
Physiography	1030	1095
Principles of Agriculture	289	386

The increase has been mainly in sound, light, and heat, and the principles of agriculture; the falling off has been chiefly in animal physiology, and magnetism and electricity. The Scotch Code differs from the English in regard to the teaching of science in several points, but the annual return does not exhibit a much more hopeful state of affairs. The importance of technical instruction is making rapid progress in popular estimation, but this subject has not got a real footing as yet in elementary schools, owing to the inaction of the Government pending a definite expression of opinion by the House of Commons.

SECTION A—Mathematical and Physical Science

On Stationary Waves in Flowing Water, Part I., by Sir William Thomson.—This subject includes the beautiful wave-group produced by a ship propelled uniformly through previously still water, but the present communication[1] is limited to two-dimensional motion.

Imagine frictionless water flowing in uniform *régime* through an infinitely long canal with vertical sides; and bottom horizontal except where modified by transverse ridges or hollows, or slopes between portions of horizontal bottom at different levels. Included among such inequalities we may suppose bars above the bottom, fixed perpendicularly between the sides. Let these inequalities be all within a finite portion, AB, of the length, and let f denote the difference of levels of the bottom on the two sides of this portion, positive if the bottom beyond A is higher than the bottom beyond B.

Now, let the water be given at an infinite, or very great, distance beyond A, perpetually flowing towards A with any prescribed constant velocity, V, and filling up the canal to a prescribed constant depth, D. It is required to find the motion of the water towards A, through AB, and beyond B as disturbed by the inequalities between A and B. This problem is essentially determinate; and it has only one solution if we confine it to cases in which the vertical component of the water's velocity is everywhere small in comparison with $\sqrt{g\text{D}}$, the velocity acquired by a falling body falling from a height equal to half the depth.

In particular cases the water flows away unruffled at great distances from B. But, in general, the surface is ruffled, and the water flows "*steadily*" between the plane bottom and a corrugated free surface, as in the well-known appearance of water flowing in a mill-lead, or Highland burn, or in the clear rivulet on the east side of Trumpington Street, Cambridge. The train of diminishing waves which we see in the wake of each little irregularity of the bottom would, of course, extend to infinity if the stream were infinitely long, and the water absolutely inviscid (frictionless); and a single inequality, or group of inequalities, in any part, AB, of the stream, would give rise to corrugation in the whole of the flow after passing the inequalities, more and more nearly uniform, and with ridges and hollows more and more perpendicular to the sides of the canal, the farther we are from the last of the inequalities. Observation, with a little common-sense of the mathematical kind, shows

[1] I have since found, in a sufficiently practical form, the solution for the wave-group produced by the ship, which I hope to communicate to the *Philosophical Magazine* for publication in the November number.—W. T., September 13, 1886.

that at a distance of two or three wave-lengths from the last of the irregularities if the breadth of the canal is small in comparison with the wave-length, or at a distance of nine or ten breadths of the canal if the breadth is large in comparison with the wave-length, the condition of uniform corrugations with straight ridges perpendicular to the sides of the canal, would be fairly well approximated to, even though the irregularity were a single projection or hollow in the middle of the stream. But the subject of the present communication is simpler, as it is limited to two-dimensional motion; and our inequalities are bars, or ridges, or hollows, perpendicular to the sides of the canal. Thus, in our present case, we see that the condition of ultimate uniformity of the standing waves in the wake of the irregularities is closely approximated to at a distance of two or three wave-lengths from the last of the inequalities.

A mathematical treatment of the problem thus presented, which will appear in the October number of the *Philosophical Magazine*, gives, among other results, the following conclusions:—

Generally, in every case when $V < \sqrt{gD}$ the upper surface of the water rises when the bottom falls, and the water falls when the bottom rises.

On the other hand, when $V > \sqrt{gD}$, the water surface rises convex over every projection of the bottom, and falls concave over hollows of the bottom; and the rise and fall of the water are each greater in amount than the rise and fall of the bottom; so that the water is deeper over elevations of the bottom, and is shallower over depressions of the bottom.

Returning now to the subject of standing waves (or corrugations of the surface) of frictionless water flowing over a horizontal bottom of a canal with vertical sides, I shall not at present enter on the mathematical analysis by which the effect of a given set of inequalities within a limited space, AB, of the canal's length, in producing such corrngation in the water after passing such inequalities, can be calculated, provided the slopes of the inequalities and of the surface corrugations are everywhere very small fractions of a radian. I hope before long to communicate a paper to the *Philosophical Magazine* on this subject for publication. I shall only just now make the following remarks:—

(1) Any set of inequalities large or small must in general give rise to stationary corrugations large or small, but perfectly stationary, however large, short of the limit that would produce infinite convex curvature (according to Stokes's theory an obtuse angle of 120°) at any transverse line of the water surface.

(2) But in particular cases the water flowing away from the inequalities may be perfectly smooth and horizontal. This is obvious because of the following reasons:—

(i.) If water is flowing over plane bottom with infinitesimal corrugations, an inequality which could produce such corrugations may be placed on the bottom so as either to double those previously existing corrugations of the surface or to annul them.

(ii.) The wave-length (that is to say, the length from crest to crest) is a determinate function of the mean depth of the water and of the height of the corrugations above it, and of the volume of water flowing per unit of time. This function is determined graphically in Stokes's theory of finite waves. It is independent of the height, and is given by the well-known formula when the height is infinitesimal.

(iii.) From No. ii. it follows that, as it is always possible to diminish the height of the corrugations by properly adjusted obstacles in the bottom, it is always possible to annul them.

(3) The fundamental principle in this mode of considering the subject is that, whatever disturbance there may be in a perpetually sustained stream, the motion becomes ultimately steady, all agitations being carried away down stream, because the velocity of propagation, relatively to the water, of waves of less than the critical length, is less than the velocity of flow of the water relatively to the canal.

In Part II., to be published in the November number of the *Philosophical Magazine*, the integral horizontal component of fluid pressure on any number of inequalities in the bottom, or bars, will be found from consideration of the work done in generating stationary waves, and the obvious application to the work done by wave-making in towing a boat through a canal will be considered. The definitive investigation of the wave-making effect when the inequalities in the bottom are geometrically defined, to which I have just now referred, will follow; and I hope to include in Part II., or at all events in Part III. to be published in December, a complete investigation, illustrated by drawings, of the beautiful pattern of waves produced by a ship propelled uniformly through calm deep water.

On a New Form of Current-Weigher for the Absolute Determination of the Strength of an Electric Current, by Prof. James Blyth.—The object of this paper is to describe a method of absolutely determining the strength of an electric current by measuring in grammes' weight the electro-magnetic force between two parallel circular circuits, each carrying the same current. For convenience of calculation the circles have the same radius, and are placed with their planes horizontal. The construction of the instrument is as follows:—A delicate chemical balance is provided, and the scale-pans replaced by two suspended coils of wire. Each of these is made of a single turn of insulated copper wire (No. 16 about) fixed in a groove round the edge of an annular disk of glass or brass of suitable diameter. The disk is made as thin and light as possible consistently with perfect rigidity. By means of two vertical pillars of brass this annulus is attached to a rigid cross-bar of dry wood or vulcanite, in the middle of which is placed a hook for suspending the whole from one end of the balance-beam. On each side of the hook, and equally distant from it, two slender rods of brass are screwed in in the wooden bar, which support two small platinum cups for holding mercury or dilute acid. The position of these cups is so adjusted that, when the whole hangs freely, the cups are in line with the terminal knife-edge of the balance-beam, and have their edges just slightly above its level. The free ends of the insulated wire surrounding the disk, after being firmly tied together for a considerable length and suitably bent, are soldered to the brass supports of the platinum cups, which thus serve as electrodes by means of which a current may be sent through the suspended coil. A precisely similar coil is suspended from the other end of the balance-beam. We now come to the arrangement by means of which a current is led through the suspended coils, so as to interfere as little as possible with the sensibility of the balance. This constitutes the essential peculiarity of the instrument, and is effected in the following way:—An insulated copper wire, having its ends tipped with short lengths of platinum, is run along the lower edge of the beam, and is firmly lashed to it by well-rosined silk thread. The ends of this wire, bent twice at right angles, are so placed that their platinum tips dip vertically into one of each pair of the platinum cups which are attached to the vertical rods of the suspended coils. From the other cup of each pair proceed two similarly tipped copper wires, which run along the upper edge of the beam, and are also firmly tied to it. These wires, however, only proceed as far as the middle of the beam, where they are bent, first outwards, one on each side of the beam, at right angles to it, and then downwards, so that the platinum tips are vertical. The latter dip into two platinum cups attached to two vertical rods, which spring from the base-board of the balance. These rods are placed at equal distances on each side of the beam, and are of such length that the platinum cups are in line with the central knife-edge of the beam and have their edges just a little above its level. There are thus in all six cups and six dipping wires. Three of these are in line on one side of the beam, and three on the other. Also the line joining the points of each pair of dipping wires is made to coincide with the corresponding knife-edge; and, further, the edges of the cups are all in the same plane when the balance is in equilibrium. From this it will be obvious that any motion of the beam in the act of weighing causes only a very slight motion of the platinum wires, which dip into the fluid contained in the cups. The resistance, due to the viscosity of the fluid, is thus very small, even in the case of mercury, and much smaller still when dilute acid is used. In point of fact, the diminution of sensibility due to this cause is less than in the case of determining the specific gravity of solids by weighing in water in the ordinary way. With clean mercury it is quite easy to weigh accurately to a milligramme. The fixed coils, constituting two pairs, have the same diameter as the suspended coils, and, like them, are made of single turns of insulated wire wound round the edges of circular disks of glass or brass. The disks of each pair are fixed at the requisite distance apart to a cylindrical block of wood, so as to have their planes exactly parallel and their centres in the same straight line. To insure this they are turned up and finished on the same cylindrical block on which they are finally to rest. When in position they are so placed that, when the balance is in equilibrium, each suspended coil hangs perfectly free to move with its plane horizontal and exactly midway between a pair of fixed coils. For this purpose, as will be seen, it is necessary that two large holes be drilled in the upper disk of each pair, so as to allow the brass pillars of the corresponding annular disk to pass freely through. When the connections are made, the current is led through the entire apparatus in such a way that, while the electro-magnetic force acting on the one suspended coil causes it to descend, the electro-magnetic force acting upon the other causes them to ascend. The total force tending to disturb the equilibrium of the balance is thus exactly four times that due to an equal current circulating in two parallel circles of the same diameter and with their planes at the same distance apart. The current-strength is estimated from the number of grammes required to restore the balance to exact equilibrium, the weights being placed into small scale-pans attached to the movable part of the apparatus. The electro-magnetic force between each fixed and the corresponding suspended coil is calculated from the formulæ given by Clerk Maxwell (vol. ii. p. 308), viz. :—

$$\frac{dM}{db} = -2\pi \cos\gamma\left\{2F\gamma - (1 + \sec^2\gamma)E\gamma\right\}$$

where M = the potential energy between two parallel circles, each carrying unit current,
b = distance between their planes,
a = radius of each coil,

$$\sin\gamma = \frac{2a}{\sqrt{4^2a + b^2}},$$

$F\gamma$ and $E\gamma$ = first and second complete elliptic integrals to modulus $\sin\gamma$.

In one of the instruments constructed

$$a = 10\cdot8 \text{ inches}, \; b = \cdot566 \text{ inches},$$

which give

$$\gamma = 87^\circ, \; F\gamma = 4\cdot338653976, \; E\gamma = 1\cdot005258587;$$

from which, if G denote the constant of the instrument and $g = 981$, we have

$$G = 4 \cdot \frac{dM}{db} \cdot \frac{1}{g} = \cdot4818.$$

This gives for 1 ampere a force = ·04818 gramme-weight.

Besides the one exhibited I have constructed several modifications of the instrument, only one of which, however, needs be particularly mentioned. In it both the fixed and movable coils are replaced by flat spirals of wire, each of eleven turns. Here the practical construction is more difficult, and the calculation of the constant somewhat more laborious, unless one is content with merely integrating over the area of both the fixed and suspended spirals. This is, I think, however, hardly legitimate, at least with thickish wires, as we thereby suppose that electricity is circulating in the insulating spaces between the wires as well as in the wires themselves. To avoid this I have actually calculated the force exerted by each one of the coils of the fixed spiral upon each coil of the suspended spiral. This entails great labour, as the elliptic integrals have to be calculated for values of the modulus differing very slightly from each other. The labour, however, is worth the taking, as the attractive or repulsive force between two flat spirals is so much greater than that between two simple circles.

The Peculiar Sunrise-Shadow o Adam's Peak in Ceylon, by the Hon. Ralph Abercromby, F.R.Met.Soc.—A great peculiarity has been noticed by many travellers about the shadow of Adam's Peak at sunrise. The shadow, instead of lying flat on the ground, appears to rise up like a veil in front of the spectator, and then suddenly to fall down to its proper level. Various theories have been propounded to account for this, and it has usually been supposed to be due to a sort of mirage. The author, in the course of a meteorological tour round the world, spent the night on the top of the peak, 7352 feet above the sea, and obtained unmistakable evidence that the appearance is due to light wreaths of thin morning mist being driven past the western side of the mountain by the prevailing north-east monsoon up a neighbouring gorge. The shadow is caught by the mist at a higher level than the earth, and then falls to its own plane on the ground as the condensed vapour moves on. The appearance is peculiar to Adam's Peak; for the proper combination of a high isolated pyramid, a prevailing wind, and a valley to direct suitable mist at a proper height on the western side of a mountain, is only rarely met with. Any idea that the appearance could be caused by mirage is completely disproved by the author's thermometric observations.

Description of a New Calorimeter for Lecture-Purposes, by T. J. Baker.—The instrument consists of two exactly similar metallic air-thermometers mounted side by side with their U-shaped thermometer-tubes adjacent, so that their indications can be easily compared with each other. The air-vessel of each thermometer contains a cylindrical well, in which the substance to be experimented with is immersed. Each well is provided with a discharging-tube furnished with a stop-cock. The scale common to both thermometers is of milk-glass, divided into 100 equal parts both above and below zero, and let into the stand so as to constitute a translucent window which can be illuminated from behind. By means of this instrument many thermal problems can be demonstrated before a large audience.

On the Distribution of Temperature in Loch Lomond and Loch Katrine during the past Winter and Spring, by J. T. Morrison, M.A.—The author made observations on the temperature of these lakes on or about the term day of each month from December 1885 to June 1886, in continuation of Mr. J. Y. Buchanan's researches. These included the whole length of Loch Katrine and the head and middle part of Loch Lomond, the deepest sounding, 99 fathoms, being got near Inversnaid in the latter lake. At Inversnaid, from December till March, the water was each month of uniform temperature from surface to bottom, the temperatures being—

December 22, 1885	42°·8
January 21, 1886	41·2
February 23, 1886	40·05
March 23, 1886	39·05

In the deepest sounding obtained on Loch Katrine, 79 fathoms, a similar distribution was met with up till February, the readings being—

December 23, 1885	(42°·3) [1]
January 22, 1886	40·4
February 24, 1886	39·0

And, though the maximum density-point was thus attained in February, uniformity still prevailed in March down to a depth of 70 fathoms, the readings on March 24 being: surface, 38°·1; 70 fathoms, 38°·1; 79 fathoms, 38°·7. In April the temperature distribution usually found in spring had set in in both lakes, the surface being warmest, the bottom coldest, and the temperature falling more and more slowly with increase of depth. The circumstance of most interest, however, is that the warmth of the bottom layer increased monthly over the deepest parts of both lakes, as follows:—

	March	April	May	June
	°	°	°	°
Loch Lomond (99 fathoms)	39·05	39·4	40·3	40·6
Loch Katrine (79 fathoms)	38·7	39·1	40·1	40·65

This rise is evidently due not to the conduction of heat nor to the penetration of solar radiation, but to some drainage or oozing causing mixture. This supposition seems necessary also to explain the behaviour of Loch Katrine in March. Drainage *en masse* appears to occur chiefly in winter and spring, not in summer when the river water and the lake surface water are much warmer than the deep water of the lake. The mean temperature of Loch Katrine probably has a greater range than that of Loch Lomond. The shallower parts of the lakes resemble the deep parts as to uniformity of temperature up till March. But their yearly range is greater. In both lakes the mean temperature becomes uniform along the whole length about April 4.

On the Distribution of Temperature in the Firth of Clyde in April and June 1886, by J. T. Morrison, M.A.—In the latter parts of April and June of this year Mr. John Murray, Dr. Mill, and the author made serial temperature soundings throughout the Clyde district, chiefly with Negretti and Zambra's reversing thermometer. It was found that in matter of temperature the waters of the district were divisible into four groups: I. North Channel and the plateau south of Arran; II. the Arran and Dunoon open basins; III. the deep-sea lochs; IV. the shallow sea lochs. The average temperature in each group at every depth was calculated for April and June, and these averages form the basis of this paper. In April in all groups there is a deep layer of uniform temperature overlaid by a layer of temperature rising steadily to the surface. In groups II., III., and IV. the uniform deep temperatures are almost the same, about 41°·4 F.; in group I. it is 41°·8 F. In June the superficial

[1] No sounding made here in December. Above temperature is calculated from that of another part of the lake.

layer of varying temperature had thickened to about 20 fathoms. The deep temperatures in the groups were now very different:—

	I.	II.	III.	IV.
Deep temperature in April ...	41°·8	41°·3	41°·5	41°·5 [1]
,, ,, June ...	46·7	43·9	43·8	45·3 [1]
Rise of temperature	4·9	2·6	2·3	3·8

To groups III. and IV. analogues are found in a deep and a shallow basin of Loch Lomond, in both of which the bottom temperature rose between April and June. From this it is inferred that land-influences, especially drainage *en masse*, produce most of the effect noticed in III. and IV. The great rise in the North Channel and southern plateau is evidently due to a warm oceanic current. The rise in temperature in group II. is due to the incoming of warm water from without. As the water between 30 and 75 fathoms in this group is very uniform in temperature, and as the south plateau is 25 fathoms below the surface, it is supposed that the dense plateau water is carried into the open basins (group II.), and through convection mixes thoroughly the water below 30 fathoms there. Loch Goil is specially remarkable for its isolation and the small rise of bottom temperature—0°·6 F. in two months. In Upper Loch Fyne a lenticular mass of water below 43°·0 F. was found in June to float between two warmer layers. Its greatest thickness, 30 fathoms, was opposite Inverary. The bottom layer of 44°·0 F. was not found to be in connection with any equally warm layer either inside or outside of the loch.

On the Critical Curvature of Liquid Surfaces of Revolution, by A. W. Rücker, M.A., F.R.S.—Let a mass of liquid film be attached to two equal circular rings, the planes of which are perpendicular to the line joining their centres. It will form a surface of revolution the equation of which is, according to Beer,—

$$y^2 = \alpha^2 \cos^2 \phi + \beta^2 \sin \phi,$$
$$x = \alpha E + \beta F,$$

where F and E are elliptic integrals of the first and second kinds respectively, the amplitude being ϕ, and the modulus $\kappa = \sqrt{\alpha^2 - \beta^2}/\alpha = \sin \theta$. If θ be conceived as increasing from 0, when it is in the first quadrant the figure will be an unduloid lying being the cylinder and the sphere, in the second quadrant a nodoid, the limits of which are the sphere and a circle. In the third and fourth quadrants the figure will be dice-box-shaped with a contraction in the middle, being a nodoid in the third and an unduloid in the fourth quadrant. The one passes into the other through the catenoid. If now we suppose the rings to be at a fixed distance apart, and the volume of the surface to be altered, the curvature will change, and the direction of the change will depend on the diameter and distance apart of the rings, and on the magnitude of the maximum or minimum ordinate (the *principal ordinate*), which lies half-way between them. The object of the paper is to investigate the general relation between these quantities when the curvature is a maximum or minimum, if the changes in the form of the film take place subject to the conditions that the diameter and distance of the rings are constant. It has been recently shown by Prof. Reinold and the author that, if these conditions hold,

$$(\alpha^2 E - \beta^2 F + \alpha^2 \Delta_1 \cot \phi_1)\delta\alpha + \alpha^2(F - E + \Delta_1 \tan \phi_1)\delta\beta = 0,$$

where ϕ_1 is the upper limit of the integrals and

$$\Delta_1 = \sqrt{1 - \sin^2 \theta \sin^2 \phi_1}.$$

Writing this in the form $A\delta\alpha + B\delta\beta = 0$, it is proved that the curvature has in general a critical value when $A - B = 0$; so that

$$2E - F(1 + \cos^2 \theta) + 2\Delta_1 \cot 2\phi_1 = 0$$

is a condition which must be satisfied by θ and ϕ_1. To find values of ϕ_1 corresponding to given values of θ the equation must be solved by trial; but it is proved that, if a pair of corresponding values is given when θ lies (say) in the first quadrant, the values of ϕ_1 can be at once found which correspond to $\pi - \theta$, $\pi + \theta$, and $2\pi - \theta$. The values of ϕ_1 corresponding to θ and $\pi - \theta$ re equal, and, if ϕ_2 be the value corresponding to $\pi + \theta$ and $\pi - \theta$, it is given by the equation

$$\tan \phi_1 \tan (\pi - \phi_2) = \sec \theta.$$

By means of these equations a curve can be drawn, showing the relations between ϕ_1 and θ, and thence are found the values of p/Y, X/p, and X/Y, where $2Y$, $2X$, and $2p$ are the diameter and distance of the rings and the magnitude of the principal diameter. If we now conceive the two rings gradually to approach or recede from each other, and the principal diameter to be altered so that the condition of critical curvature is always fulfilled, it is proved that the changes in its form would be as follows:—Beginning with the cylinder, the distance of the rings would (as has been shown by Maxwell, Art. "Capillarity," "Enc. Brit.") be half their circumference. As the diameter increases, the rings would move apart, and the distance between them would be a maximum when $\theta = 64°·2$, being 17 per cent. greater than in the case of the cylinder. When $\theta = 90°$, the figure is a sphere, and the distance between the rings is about 4 per cent. less than in the case of the cylinder. The sphere has a larger diameter than any other figure of critical curvature. The surface next becomes a nodoid, and the distance between the rings diminishes till when $\theta = 180°$ they touch, and thus the surface reduces to a circle. In the next quadrant the rings separate, but the figure is now dice-box-shaped, and the pressure exerted by the film is outwards. When $\theta = 270°$, the figure is the catenoid. The principal ordinate is then less than that of any other figure of critical curvature, and the radius of the rings is a mean proportion between this minimum ordinate and the maximum which was attained in the case of the sphere. The same relation holds between the principal ordinates of any two figures which correspond to values of θ which differ by 180°. In the fourth quadrant the figure becomes an unduloid, the pressure is inwards, the rings continue to separate, and the ratio of the distance between the rings to the principal ordinate is a maximum when $\theta =$. In the paper tables and curves are given to illustrate the "march" of these functions. To secure continuity, the problem is discussed without reference to the question as to whether the surfaces are in stable equilibrium, though those in the first and fourth quadrants and figures corresponding to values of θ not much $> \pi/2$ and not much $< 3\pi/2$ certainly are. In conclusion it is shown that by means of the curves we can solve a number of problems with sufficient accuracy for practical purposes. Thus, if any two of the three quantities, the diameter of the rings, the distance between them, and the diameter of the surface of critical curvature, are given, the third can be found.

[1] Average temperature of first few fathoms above bottom.

SECTION B—CHEMICAL SCIENCE

Absorption Spectra of Uranium Salts, by Dr. W. J. Russell and W. J. Lapraik.—This paper was communicated by Dr. Russell, who pointed out that well-marked absorption bands in the visible spectrum are produced by the different salts of this metal; the bands produced by the uranous salts are distinct from those given by the uranic salts; both consist, however, of three distinct bands or groups of bands. The bands produced by the uranous salts are at the red end of the spectrum, whilst those due to the uranic salts are at the blue end; and when both classes of salts are mixed in solution there are three series of bands distributed with tolerable regularity over the whole of the spectrum. Experiments with different salts show the nature of the acid radical to have no influence on the spectrum, whereas in the case of other metals, such as cobalt, it has been found that different radicals produce different spectra. The spectrum common to all uranic salts is slightly altered by the addition of free acid; a diminution in intensity in the least refrangible bands and a slight shift in others has been observed. Crystals of uranic nitrate give an absorption spectrum similar to that produced by its solutions. The spectrum of the uranous salts is less refrangible than that of the uranic salts; the examination of the spectra produced by the uranous salts in the solid state was found to be more complex than those given by these salts in solution.

The Air of Dwellings and Schools, and its Relation to Disease, by Prof. Carnelly.—The author gave an account of an elaborate series of experiments conducted by him and Dr. Haldane at Perth and Dundee, in connection with the sanitary and school authorities, the object being to determine the relations between the composition of the air and the death-rate in houses and schools, and also the effect of various systems of ventilation. For this purpose the carbon dioxide, organic matter, and micro-organisms were determined, both in the outside air and in the room to be examined. In the air of the towns of Perth and Dundee a distinct increase of impurities could be detected in close parts of the towns as compared with the open spaces. In examining the dwelling-houses, the experimenters had authority from the sanitary officers, and visited bed-rooms and similar places during all parts of the day or night, while actually occupied by the inhabitants. Houses are divided in the tables into one-, two-, and four-roomed dwellings, and mention was made of some cases in single-roomed dwellings in which eight persons were found sleeping in a single bed, and in many cases no bed was found in the dwelling at all. The impurities in the air of such houses were naturally much greater than in better class, and by a careful comparison of chemical composition of the air with the death-rates from various causes in the various classes of houses, it was shown that on an average the length of life in a one-roomed house was only twenty years, whilst that in better-class houses is forty years. Hence a person born and living in a one-roomed house has a chance of living only half as long as those born and living in a four-roomed house. This depends naturally to a considerable extent on other causes than impure air-supply. Some irregularity was observed in the cases of consumption, scarlet fever, and diphtheria, which is, however, quite capable of explanation. The influence of cubic space on the purity of the air in dwelling-rooms was somewhat unexpected, the best results being noticed when 1000 cubic feet was allowed for each person. With larger rooms, owing to stagnation of the air, the result is not so good. Sixty-eight schools in Dundee were examined; of these, twenty-six were mechanically ventilated, while the others were ventilated by means of windows. The advantages were distinctly in favour of mechanical ventilation, the micro-organisms being one-seventh, and the carbon dioxide one-half of that in the other schools. Mechanical ventilation not only materially improves the quality of the air, but also has less influence in unduly reducing its temperature. On comparing together boys' and girls' schools the air is almost invariably less pure in boys' schools. The amount of carbon dioxide does not afford any indication of the amount of organic matter or micro-organisms, except by taking the mean of a large number of experiments. Cleanliness of person has a comparatively small influence on the number of micro-organisms, but cleanliness of dwelling-rooms and schools has a most important effect. Hence the air of new schools is distinctly better than that of older buildings. In conclusion, the author suggested that in many cases the evil said to be due to over-pressure in schools was doubtless due to imperfect ventilation, and that if Dundee may be fairly regarded as an example of a British town, then certainly our schools are most imperfectly ventilated; and that for improvement in this respect the advantage of mechanical ventilation should be strongly insisted upon.

The Preservation of Gases over Mercury, by H. B. Dixon, M.A., F.R.S.—From a statement in Bence-Jones's "Life of Faraday" it would appear that a difference of opinion between Faraday and Davy existed on this point, and according to the experiments of the former gases cannot be indefinitely preserved over mercury, whilst the latter found that hydrogen could be preserved over mercury for a considerable time without suffering change. The author has examined various gases, including hydrogen, cyanogen, sulphur dioxide, and electrolytic gas, which had been kept over mercury for periods ranging from 2½ to 9½ years, and concludes that the gases had suffered no change in the time.

The Distribution of the Nitrifying Organism in the Soil, by R. Warington, F.R.S.—Previous experiments have shown the limit of depth at which this organism exists in soil to be about 18 inches, but later experiments have shown it to exist at depths of 3 feet, and in some cases at depths of 5 and 6 feet.

The Fading of Water-Colours, by Prof. W. N. Hartley, F.R.S.—The author, referring to the correspondence in the *Times* and to an article in the *Nineteenth Century* on this subject, pointed out that two ideas had been brought forward in connection with this matter—one being that water-colour drawings fade on keeping, while others have contended that the tints increase in depth on keeping for a length of time. Hence, on the one hand it has been recommended to keep water-colour drawings in the light, while others have suggested that darkness is preferable. Colours used are of two kinds, mineral and organic. Mineral colours are generally unalterable, except in special colours, such as lead. The tendency is for red light to act as an oxidising agent on such colours, while violet light exerts a reducing action. But in the case of organic colouring-matters oxidation is promoted by light from either end of the spectrum. Acidity in any form is a great cause of the deterioration in water-colours. The chief sources of acidity are the impurities in the atmosphere in presence of moisture, imperfectly prepared colours, and the acidity of the paper. The paper is always itself slightly acid, and the use of size or gum is a source of acidity, while the burning of coal and of gas in towns produces a sensible amount of sulphurous acid in the atmosphere. The author has carefully examined the effect of acids, of exposure to sunlight, of hydrogen peroxide, and of sulphurous acid in the case of sixteen common water-colours. As a result he concludes that the character of the colours examined is very creditable to the manufacturer. Lakes are very permanent in pure air; while cases are known where indigo has remained unchanged for upwards of 1800 years. Indigo is, however, liable to be attacked by acids. Generally the effect of chemical agents upon water-colours is what might have been expected from their chemical composition. Thus yellows containing cadmium sulphide are bleached by oxidising agents. In some few cases, however, unexpected results were obtained. Ultramarine is very readily affected by dilute acids; no preparation of lead should be used as a pigment either for oil or water-colour drawing. It is shown that many water-colour drawings have been exposed to light for fifty years or more in properly arranged galleries, without appreciable deterioration. The tendency is to produce apparently darker tints, owing to the lighter tints being most likely to fade, while the brown colour developed in the paper itself tends to produce a similar effect. To preserve delicate sunlight effects the drawings should be kept in rooms imperfectly illuminated, and preferably with blinds transmitting a yellow or brown light. They should be carefully protected from the effects of an impure atmosphere, while paste or gum should not be used in affixing them. A slight wash of borax on the paper destroys its acid reaction, and makes the colours fix readily on the fibres. A small quantity of borax might be used in the water employed for mixing the colours. For illuminating galleries incandescent lamps are to be preferred to lighting by the electric arc, as the latter may be regarded as a sure means of destruction of the colours.

The Colour of the Oxides of Cerium and its Atomic Weight, by H. Robinson, M.A.—A criticism of the work of Wolf, on the atomic weight of cerium, published in the *American Journal of Science and Art*, 1868, upon which the atomic weight, 138 cerium, given in Clark's "Constants of Nature," is based. The author contends that Wolf's method of preparation would give lanthanum and not ceric oxide; experimental evidence was given in support of this contention; further the author maintains that ceric oxide is yellow and not white, as described by Wolf.

On the Relative Stability of the Hydrochloride $C_{10}H_{17}Cl$ Prepared from Turpentine and Camphene respectively, by E. F. Ehrhardt (Mason College).—According to Ribau the first of these hydrochlorides is the less easily decomposed by water, whereas the author finds it to be the one most easily decomposed under the influence of temperature. At a low red heat Tilden has shown turpentine is more completely dissociated than camphene, and this the author has shown to be true for lower temperatures. The paradoxical result that the hydrochloride of the more stable hydrocarbon is less stable than that from the unstable one, is regarded as proving this compound to be a molecular one, in which the chlorine is associated with the hydrogen of the acid and at the same time to the hydrocarbon.

On Derivatives of Tolidine and Azotolidine Dyes, by R. F. Ruttan, B.A., M.D.—An account of the preparation of tolidine, which is the homologue of benzodine, and obtained by a similar mode of preparation. Several derivatives of this base wer described, as also azotolidine or tetra-azoditolyl, which is produced by the action of nitrous acid on the base. This compound forms the starting-point in the preparation of a series of important dyes, by which cotton and wool fibre may be dyed without the use of a mordant.

On the Chemistry of Estuary Water, by H. R. Mill, D.Sc.—The salinity (ratio of total dissolved matter in water) has been determined from point to point in the Firth of Clyde and Firth of Forth. In the case of the latter the distribution of salinity has been shown to be constant all the year round, whilst in the case of the Clyde there are periodical variations through the whole mass of the water. In the case of the Forth River entrance, it is evident a mixture of river and sea water takes place by a true process of diffusion, maintaining a constant gradient from river to sea. The dissolved matter of fresher water was found richer in calcium carbonate than sea water.

The Essential Oils; a Study in Optical Chemistry, by Dr. Gladstone, F.R.S.—After explaining how the refractive equivalent of an organic compound may be used to determine its constitution, the author pointed out that the dispersion equivalents can be similarly used. The author also discussed the refraction and dispersion equivalents of the turpenes, citrenes, camphor, and of some other members of the group of essential oils, and showed how these values were of service in determining the constitution of these bodies.

An Apparatus for Maintaining Constant Temperatures up to 500° C., by G. H. Bailey, D.Sc., Ph.D.—The substance to be heated is placed in a glass tube, together with the bulb of an air-thermometer, which are inclosed in a wider tube resting on the iron casing of a furnace. The air-thermometer serves to measure the temperature, and is connected with a gas regulator, by which means the temperature may be kept constant at any desired temperature below that at which combustion-glass softens.

Treatment of Phosphoric Crude Iron in Open-Hearth Furnaces, by J. W. Wailes.—The process is similar to the ordinary puddling operation, and is conducted in a furnace with a basic lining; the metal is, however, removed from the furnace in a molten condition.

Notes on the Basic Bessemer Process in South Staffordshire, by W. Hutchinson.—The process described differs from the ordinary basic process inasmuch as the converting is conducted in two stages: (1) desiliconising of the metal in an acid-lined converter; (2) the dephosphorising in a converter with a basic lining.

Production of Soft Steel in a New Type of Fixed Converter, by G. Hatton.—Description of a converter, which is claimed to have many advantages over the Bessemer converter.

T. Turner, Assoc. R.S.M. (Mason College), read a series of papers relating to the chemistry of iron and steel. The first was *On the Influence of re-melting on the Properties of Cast Iron*. No general rule can be laid down as to the influence of re-melting on the properties of cast iron; chemical changes take place during the melting: the amount of silicon is reduced whilst that of the sulphur is increased, and the effect of re-melting will be dependent upon the proportion of these elements present in the cast iron; a single melting will be sufficient to produce a deterioration in the qualities unless the silicon is in excess. A second paper was *On Silicon in Cast Iron*. Addition of silicon to hard white iron causes it to become soft and grey, and too much silicon makes the iron weak; by adding silicon in right proportion cast iron can be made of any desired degree of hardness. The third communication was one *On Silicon in Iron and Steel*. The author has succeeded in making a steel in which the carbon is replaced by silicon, which can be hardened like steel, is very tough when cold, and is well adapted for tools, but is difficult to work when hot. The author gave a short description of a method for estimating carbon in iron or steel.

A New Apparatus for Readily Determining the Calorimetric Value of Fuel and Organic Compounds, by W. Thomson, F.R.S.E.—The apparatus-described is an improved form of the calorimeter due to Lewis Thompson; the substance is burnt in a stream of oxygen instead of mixing it with potassium chlorate, as recommended by Thompson.

On some Decompositions of Benzoic Acid, by Prof. Odling, F.R.S.—When benzoic acid is heated in sealed tubes at about 260° with an aqueous solution of zinc chloride, it is decomposed, and yields chiefly benzene, together with a small quantity of diphenyl.

On the Methods of Chemical Fractionation and *The Fractionation of Yttria*, by W. Crookes, F.R.S.—In the Presidential address this subject was referred to, and in this communication a detailed account of the operation of "fractionation" is given. Fractionation, briefly, consists of first fixing upon some chemical reaction in which there is a likelihood of a difference existing in the behaviour of the elements under treatment; this is then performed in an incomplete manner, so that only a portion of the total bases present is separated, the object being to get part of the material in the insoluble and the rest in the soluble state. In the second communication the author described the fractionation of the earth yttria; in this case the fractionation has been greatly facilitated by the use of what the author styles the "radiant-matter test," which is dependent upon the spectra given by these earths when phosphoresced *in vacuo*. It would appear that there are certainly five, and probably eight, constituents into which yttrium may be split.

SECTION C—Geology

Geysers of the Rotorua District, North Island of New Zealand, by E. W. Bucke.—The author of this paper has recently returned from the Lake district of New Zealand, where he spent eighteen months, and had exceptional opportunities for making observations upon the volcanic phenomena of the district. The largest geyser in New Zealand, that of the White Terrace of Rotomahana, is now destroyed. The author determined by soundings the depth of the tubes of several geysers of this district, and in the case of an extinct one, that of Te Waro, he was let down the tube. He found that this tube, 13 feet from the surface, opened into a chamber 15 feet long, 8 feet broad, and 9 feet high, from one end of which chamber another tube led downwards to an undetermined depth. Living among the natives for months, and speaking their language, the author was convinced that by constant observations on the direction of the wind and the condition of the atmosphere they have learnt to prognosticate the movements in all these hot springs with wonderful accuracy. He was also able to prove that during the whole time of his residence in the district certain of the geysers were only in eruption when the wind blew from a particular quarter.

On the Glacial Erratics of Leicestershire and Warwickshire, by the Rev. W. Tuckwell.—Gives evidence of a south-western dispersion from Charnwood. In Stockton, a village midway between Leamington and Rugby, is boulder-clay containing abundance of Mount Sorrel granite, of so-called gneiss from Charnwood Forest, largely decomposed "pockets" of red sandstone, blocks of grey sandstone highly glaciated, Bunter pebbles, flints, Carboniferous limestone, Lias rock of a different texture from that native to the district. Lying loose in the village street, recently inclosed and inscribed, is a fine boulder from Mount Sorrel, glaciated, of nearly two tons weight. The author notes extraordinary profusion of Mount Sorrel erratics as far as Leicester; at Rothley, Thurcaston, Anstey; "Stone," or "Ston," is a suffix of nearly all the villages along the line. The largest boulder found in Leicestershire is near Humberston, estimated at twenty tons, partly embedded in boulder-clay which is filled with Bunter pebbles and rolled slate from Charnwood. Charnwood stones re-appear north and south of Coventry, at Eathorpe, 6 miles south-west of Coventry, at Stockton, completing evidence of a south-west stream from the Charnwood elevation throughout the two counties.

Manganese Mining in Merionethshire, by C. Le Neve Foster, D.Sc.—Manganese ore is now being worked in the Cambrian rocks at several places near Barmouth and Harlech. It occurs in the form of a bed varying from a few inches to 3 feet in thickness; the average thickness is 1 foot to 1½ foot. The undecomposed ore contains the manganese in the form of carbonate, with a small proportion of silicate; but at the outcrop it is changed into a hydrated black oxide. Some of the outcrops of the manganese bed are erroneously marked on the Geological Survey maps as mineral veins, though Sir Andrew Ramsay was of opinion that the deposits were not true lodes. Recent workings show plainly that the deposits are truly stratified beds, or possibly various outcrops of one and the same bed, extending over a considerable area. The ore contains from 20 to 35 per cent. of metallic manganese, and is despatched to Flintshire and Lancashire for the manufacture of ferro-manganese. The new Merionethshire mines are the first instance of workings for carbonate of manganese in the British Isles.

On the Silurian Rocks of North Wales, by Prof. T. McKenny Hughes, M.A., F.G.S.—The author begins by describing some sections in the Silurian rocks of North Wales, giving lists of fossils from the various horizons in each. He then, by means of these and by what he calls syntelism, that is, the occurrence of similar sequences of beds of the same characters, lithological or other, points out the corresponding parts of the various sections described. He then does the same for the Silurian of the eastern borders of the Lake district, and, having in this manner constructed a vertical section of each, compares the two districts and shows that there is an identical series in each, with all the important zones of one represented in the other, except that in the part of North Wales which he has worked out he has not yet detected beds as high as the newer part of the series in the Lake district.

Note to accompany a Series of Photographs prepared by Mr Josiah Martin, F.G.S., to illustrate the Scene of the recent Volcanic Eruption in New Zealand, by Prof. J. W. Judd, F.R.S., Pres.G.S.—Owing to the great enterprise and energy shown by the managers of the local newspaper press in New Zealand very full and graphic accounts of the volcanic outburst of June 10 have already reached this country, and have been copied into the English papers. On the day of the eruption, Dr. James Hector, C.M.G., F.R.S., the Director of the Geological Survey of New Zealand, started for the locality, and his preliminary report, accompanied by maps and plans, has been published. Dr. Hector concludes that the eruption was a purely hydrothermal phenomenon on a gigantic scale, and that it was unaccompanied by any ejection of freshly molten lava either in the form of fragmental matter or of lava-streams. I have been favoured by Mr. J. E. Clark, F.G.S., with specimens of the material ejected during the eruption, and the microscopic examination of these entirely supports Dr. Hector's conclusions. It is a most unfortunate circumstance that the beautiful sinter-terraces of Rotomahana appear either to be blown to fragments or covered up under the enormous masses of mud thrown out in that locality. It luckily happens that a number of most excellent photographs, which illustrate very beautifully the characters of the wonderful sinter-formations, have been obtained. Mr. Josiah Martin, F.G.S., has especially devoted himself to the study of the district, and the series of photographs now exhibited constitute an invaluable record of the characters of the district destroyed by the eruption. These photographs show the points at which the volcanic cones were formed upon Tarawera, and the beautiful characters of the White Terrace (Te Terata), and of the Pink Terrace (Otukapuarangi), and the other wonders which surround the now destroyed Lake of Rotomahana. Now that the European settlement has been formed at Rotorua, a great service would be rendered to science if a meteorological station could be established there, and by simultaneous observations of the atmospheric conditions, and of the state of activity of the numerous hot springs, the question of the exact relations between these two sets of phenomena clearly established. When we remember that a fall of 1 inch in the barometer is equivalent to the removal of a load of nearly 90,000 tons over every square mile of surface, the effect produced on a district where steam issues whenever a walking-stick is thrust into the ground must be enormous. What is especially needed, however, by vulcanologists is a carefully tabulated series of records in the place of the general statements which have hitherto been published on this most important question.

The Relations of the Middle and Lower Devonian in West Somerset, by W. A. E. Ussher, F.G.S.—It has been suggested by Mr. Champernowne that the Foreland and Hangman grits might really be the same series, the appearance of conformable superposition of Lynton upon Foreland beds at Oare being ascribed to inversion. According to this view the downthrow of the fault at Oare would be to the north. The paper discusses this suggestion, its important bearing on the mapping of the area entitling it to consideration. The author advances five points in favour of the hypothesis, and three adverse to it, and gives some reasons why such difficulties as are experienced in drawing boundaries between the Foreland grits and Hangman beds might reasonably be expected to occur. The arguments against the identity of the Foreland and Hangman groups are too strong to be entertained without positive evidence in its favour. The author then briefly disposes of the possibility of the absence of the Lynton beds east of Luccot Hill being due to unconformable overlap of Hangman upon Foreland rocks, pointing out that if such were the case conglomerates ought to be found in the Hangman series, and the junction should also be marked by discordant relations of dip and strike.

A Scrobicularia Bed, containing Human Bones, at Newton-Abbot, Devonshire, by W. Pengelly, F.R.S., F.G.S., &c.—Description of a bed of fine sandy mud, 10 feet thick, crowded with *Scrobicularia piperata*, recently discovered near the head of the tidal estuary of the River Teign, Devonshire. Its top is 1 foot above the level of the highest spring tides in the estuary, and its bottom 3 feet above the low-water level. Ten feet down in the bed were found the following human bones: a skull, part of the left superior maxilla, containing two teeth, a right femur, and a right scapula—all believed to be of the age of the deposition of that part of the bed in which they lay. From the presence of the *Scrobicularia* there is apparently no doubt that since the era of deposition the district has been upheaved not less than 14 feet, nor more than 27 feet, and that the time was in all probability that of the elevation of the raised beach of Hope's Nose, about seven miles south-east of the *Scrobicularia* bed.

On a Deep Boring for Water in the New Red Marls (Keuper Marls) near Birmingham, by W. Jerome Harrison, F.G.S.—Around Birmingham the Keuper sandstone is divided from the Keuper marls by a line of fault running from north-east to south-west, roughly along the line of the River Rea. West of this fault the Keuper sandstone occupies the surface, and yields an enormous and unfailing supply of pure water, the Birmingham Corporation alone pumping about eight million gallons daily from three deep wells in this formation. East of the line of fault the Keuper red marls form an undulating band from five to twelve miles in width, the towns and villages on which depend wholly on surface waters, or shallow wells in surface gravels, for their water-supply. As the Keuper sandstone undoubtedly underlies the Keuper marls throughout the whole or the greater part of this tract of East Warwickshire, it is not surprising that attempts have recently been made to reach its locked-up waters by means of deep borings. Some seven or eight years ago the Birmingham Corporation bored in Small-heath Park (the southern suburb of Birmingham) to a depth of 440 feet, entirely in Keuper marls. The object of this paper is to describe a boring made during the present year at King's Heath, three miles south of Birmingham, at the brewery of Messrs. Bates, in search of water, which is now 667 feet deep, and still in marls and shales. From comparisons with the Keuper marls of Staffordshire, &c., the thickness of the Keuper marls at King's Heath can hardly be more than 700 feet. It is to be hoped that the Keuper sandstone will be reached almost immediately, and that its water-bearing properties will be such as to satisfy the requirements of the district.

On an Accurate and Rapid Method of Estimating the Silica in an Igneous Rock, by J. H. Player, F.G.S., F.C.S.—This paper describes a method of estimating the silica in igneous rocks by (1) fusing the finely ground rock with a flux prepared by mixing carbonates of potash and soda and nitrate of potash; (2) disintegrating the glass so obtained by the action of strong nitric acid; (3) driving off nitric acid at a temperature just below 250°, thus rendering all silica insoluble; (4) treating with hydrochloric acid, to leave the silica with some impurity, for weighing after calcination; (5) separating the impurity by means of ammonium fluoride and weighing it.

Notes on some Sections in the Arenig Series of North Wales and the Lake District, by Prof. T. McKenny Hughes, M.A., F.G.S.—In this paper the author describes a number of sections which cross the Arenig series in different parts of England and Wales, and endeavours to explain some apparent discrepancies in what is generally a remarkably constant set of beds. He starts with the Portmadoc section, where he considers that the chief differences of opinion have arisen from mistakes in the explanation of the geological structure of the district, especially from the wrong identification of some grit bands on opposite sides of important faults. Following the series to the north he shows that, although they vary in thickness, the principal zones are still represented near Carnarvon; and, discussing the question of the unconformity of these beds on the Lower Cambrian, he points out that the Lower Cambrian rocks are seen to vary so much both in character and thickness within short distances in the neighbourhood of the existing outcrop of the Archæan that any argument founded upon their thinning-out or their different texture must be received with distrust in an area where they are known to have been deposited on the flanks of mountain-ranges of pre-Cambrian age. He then describes some localities in the Lake district where the occurrence of the same zones has been determined, and points out the difficulty of getting rid of such great thicknesses of deposits of fine mud as would be implied in the usual interpretation of those areas.

On the Rocky Mountains, with Special Reference to that part of the Range between the 49th Parallel and Head-waters of the Red Deer River, by George M. Dawson, D.S., F.G.S., &c., Assistant Director, Geological Survey of Canada.—The term "Rocky Mountains" is frequently applied in a loose way to the whole mountainous belt which borders the west side of the North American continent. This mountainous belt is, however, preferably called the Cordillera region, and includes a great number of mountain systems or ranges, which on the 40th parallel have a breadth of not less than 700 miles. Nearly coincident with the 49th parallel, however, a change in the general character of the Cordillera region occurs. It becomes comparatively strict and narrow, and runs to the 56th parallel or beyond with an average width of about 400 miles only. This portion of the western mountain region comprises the greater part of the province of British Columbia. It consists of four main ranges, or, more correctly, systems of mountains, each including a number of component ranges. These mountain systems are, from east to west:—(1) The Rocky Mountains proper. (2) Mountains which may be classed together as the Gold Ranges. (3) The system of the Coast Ranges of British Columbia, sometimes improperly named the Cascade Range. (4) A mountain system which in its unsubmerged portions constitutes Vancouver and the Queen Charlotte Islands. The present paper refers to the Rocky Mountains proper. This system, between the 49th and 53rd parallels, has an average width of about sixty miles, which, in the vicinity of the Peace River, on the 56th parallel, decreases to about forty miles. It is bounded to the east by the Great Plains, which break into a series of foot-hills along its base; to the west by a remarkably straight and definite valley occupied by portions of the Columbia, Kootanie, and other rivers. Since the early part of the century the trade of the fur companies has traversed this range, chiefly by the Athabasca and Peace River Passes, but till the explorations effected by the expedition under Capt. Palliser in 1858-59, nothing was known in detail of the structure of the range. During the progress of the railway explorations a number of passes were examined, and in 1883 and 1884 that part of the range between the 49th parallel and latitude 51° 30′ was explored and mapped in some detail in connection with the work of the Canadian Geological Survey by the author and his assistants. Access to this, the southern portion of the Rocky Mountains within Canadian territory, being now readily obtained by the railway, its mineral and other resources are receiving attention, while the magnificent alpine scenery which it affords is beginning to attract the attention of tourists and other travellers. The results of the reconnaissance work so far accomplished are here presented in the form of a preliminary map, accompanied by descriptions of routes and passes, and remarks on the main orographic features of the range.

Surface Subsidence caused by Lateral Coal-Mining, by Prof. W. Benton, A.R.S.M.—A paper showing that a large amount of coal is annually sacrificed in British mining for the lateral support of neighbouring and disinterested surface proprietaries; pointing out the results of this sacrifice, and enumerating the considerations which should govern the extent of this support.

A New Form of Clinometer, by John Hopkinson, F.L.S., F.G.S.—A "day and night" compass-card is set to true north over the compass-needle, which necessarily points to magnetic north. The diameter of the card is less than the length of the needle, so that the points of the needle project beyond the card, and the correction made is seen and can be adjusted when required. The same result would be attained by placing the card below the needle. The clinometer dip is as usual below the magnetic needle, and can be easily seen outside the compass-card. The advantage of being able to take the amount and direction of the dip of strata with a single instrument without loss of time and liability to error in making the correction for magnetic deviation, and at the same time having the points of the compass exposed for more minute observations if required, must be obvious. The present deviation is 17° 50′ W. of N., and it is lessening. The instrument was exhibited.

Statistics of the Production and Value of Coal Raised within the British Empire, by Richard Meade, Mining Record Office.—This paper, prepared at the request of the Committee to accompany other papers on the Colonial coal resources, gave particulars of the quantity and value of coal raised for several years past, in many cases for ten years. We give here only the amount and value quoted for the latest year in each case:—

	Date	Quantity Tons	Value £
Queensland	1885 ...	209,500 ...	not given
New Zealand ...	1883 ...	408,831 ...	360,622
Victoria	1884 ...	not given ...	3,280
Natal	1883 ...	5,000 ...	1,000
India	1883 ...	1,315,976 ...	657,988
Cape of Good Hope	1884 ...	9,000 ...	7,250
Tasmania	1884 ...	7,194 ...	6,381
Canada	1884 ...	1,876,643 ...	619,336
United Kingdom	1885 ...	159,351,418 ...	41,139,408

On Canadian Examples of Supposed Fossil Algæ, by Sir William Dawson, LL.D., F.R.S.—Markings of various kinds on the surfaces of stratified rocks have been loosely referred to Algæ or Fucoids under a great variety of names; and when recently the attempt was made in Europe more critically to define and classify these objects, a great divergence of opinion developed itself, of which the recent memoirs of Nathorst, Williamson, Saporta, and Delgado may be taken as examples. The author, acting on a suggestion of Sir R. Owen, was enabled, in 1862 and 1864, by the study of the footprints of the recent *Limulus polyphemus*, to show that not merely the impressions known as *Protichnites* and *Climactichnites*, but also the supposed Fucoids of the genera *Rusophycus*, *Arthrophycus*, and *Cruziana* are really tracks of Crustacea, and not improbably of Trilobites and Limuloids ("On Footprints of Limulus," *Canadian Naturalist*, 1862; "On the Fossils of the Genus *Rusophycus*," *ibid.* 1864). He had subsequently applied similar explanations to a variety of other impressions found on Palæozoic rocks ("On Footprints and Impressions of Aquatic Animals," *American Journal of Science*). The object of the present paper was to illustrate, by a number of additional examples, the same conclusions, and especially to support the recent results of Nathorst and Williamson. *Rusichnites*, *Arthrichnites*, *Chrossochorda*, and *Cruziana*, with other forms of so-called *Bilobites*, are closely allied to each other, and are explicable by reference to the impressions left by the swimming and walking feet of Limulus, and by the burrows of that animal. They pass into *Protichnites* by such forms as the *P. Davisii* of Williamson, and *Saerichnites* of Billings, and *Diplichnites* of the author. They are connected with the worm-tracks of the genus *Nereites* by specimens of *Arthrichnites*, in which the central furrow becomes obsolete, and by the genus *Gyrichnites* of Whiteaves (*Transactions* of the Royal Society of Canada, 1883). The tuberculated impressions known as *Phymatoderma* and *Caulerpites* may, as Zeiller has shown, be made by the burrowing of the mole-cricket, and fine examples occurring in the Clinton formation of Canada are probably the work of Crustacea. It is probable, however, that some of the later forms referred to these genera are really Algæ related to *Caulerpa*, or even branches of Conifers of the genus *Brachyphyllum*. *Nereites* and *Planulites* are tracks and burrows of worms, with or without marks of setæ, and some of the markings referred to *Palæochorda*, *Palæobhycus*, and *Scolithus* have their places here. Many examples highly illustrative of the manner of formation of these impressions are afforded by Canadian rocks. Branching forms referred to *Licrophycus* of Billings, and some of those referred to *Buthotrephis*, Hall, as well as radiating markings referable to *Scotolithus*, *Gyrophyllites*, and *Asterophycus* are explained by the branching burrows of worms illustrated by Nathorst and the author. *Astropolithon*, of the Canadian Cambrian, seems to be something organic, but of what nature is uncertain. *Rhabdichnites* and *Eophyton* belong to impressions explicable by the trails of drifting sea-weeds, the tail-markings of Crustacea, and the ruts ploughed by bivalve mollusks. *Dendrophycus*, *Dictyolites*, some species of *Delesserites*, *Aristophycus*, and other branching and frond-like forms, were shown to be referable to rill-marks, of which many fine forms occur in the Carboniferous of Nova Scotia, and also on the recent mud-flats of the Bay of Fundy. The genus *Spirophyton*, properly so called, is certainly of vegetable origin, but many markings of water-action, fin-marks, &c., have been confounded with these so called "Cauda-galli Fucoids." On the other hand, some species of *Palæophycus*, *Buthotrephis*, and *Sphenothallus* were shown to be true Algæ, by their forms and the evidence of organic matter, and *Haliserites*, *Barrandeina*, and *Nematophycus* were shown to include plants of much higher organisation than the Algæ. With reference to the latter, it was held that the form to which the name *Prototaxites* had been given was really a land plant growing on the borders of the sea, and producing seeds fitted for flotation. On the other hand, certain forms to which he had given the name *Nematoxylon* were allied to Algæ in their structure, and may have been of aquatic habit; very perfectly preserved specimens of these last had been recently found, and had thrown new light on their structure. The author proposed to apply to all these problematical plants, having a tissue of vertical and horizontal tubes, the general name *Nematophyteæ* or *Nematophyton*. The paper referred to the history of opinion on these objects and the bibliography of the subject; but this, as well as detailed descriptions, are omitted in this abstract.

Notes on some of the Problems now being Investigated by the Officers of the Geological Survey in the North of Ireland, chiefly in Co. Donegal, by Prof. E. Hull, LL.D., F.R.S.—The author stated that the investigations of the Survey were confined to the counties of Antrim and Donegal, and, restricting his observations to the latter, he said the problem was whether or not there were two great series of metamorphic rocks unconformable to each other, the older referable to the Archæan age, the newer to the Lower Silurian. Some reference was made to the great faults and foldings of these beds, which were stated to range generally in N.N.E. and S.S.W. lines. It was considered that the granites might belong to at least two periods—the intrusive being distinct both in age and structure from the metamorphic granite and gneiss. Other points noticed were the occurrence of numerous basaltic dykes, probably of Tertiary age, traversing the gneissose rocks; and marginal representatives of the Lower Carboniferous period.

On the Classification of the Carboniferous Limestone Series; Northumbrian Type, by Hugh Miller, F.R.S.E., F.G.S., of H.M. Geological Survey.—The object of this paper was to show that the classification proposed twenty years back by G. Tate of Alnwick is still sufficient, not only for North Northumberland, where Tate established it, but also for the south of the county. Prof. Lebour has proposed another classification on the assumption that Tate's divisions either do not exist in Nature, or do not persist throughout the county. Tate's classification, amplified in some not very important details, and adapted to the work of the Geological Survey, is as follows:—

		Feet
Upper Limestone Series	*Felltop or Upper Calcareous Division:—From the Millstone Grit to the zone of the Great Limestone.* Sandstones and shales; one or more beds of marine limestone, including the Felltop Limestone; some coals	350-1200
	Calcareous Division:—From the great Limestone to the bottom of the Dun or Redesdale Limestone. Many beds of good marine limestone; sandstones and shales; coals	1300-2500
Lower Limestone Series	*Carbonaceous Division (Scremerston Beds of North Northumberland:—From the Dun or Redesdale Limestone to Tate's "Tuedian Grits."* Strata prevalently carbonaceous; limestones chiefly thin, many of them containing vegetable matter; coals	800-2500
	Tuedian Division:—Upper Tuedian or Fell Sandstone Group, the "Tuedian Grits" of Tate:—From the Carbonaceous Group to the Cement-Limestones. Great belt of massive grits (Tweedmouth, Chillingham, the Simonside, and Harbottle Hills, the Peel, and Bewcastle Fells). Shales greenish and reddish as well as carbonaceous gray; coals rare, thin, or absent ...	500-1600
	Lower Tuedian or Cement-Limestone Group:—From the base of the Grits downwards. Cement-stone bands passing into limestones (Rothbury, Bewcastle); coals very rare; generally some coloration of the shales and sandstones	500-1500
	Basement Conglomerates (Upper Old Red Sandstone); local	—

Notes on the Crystalline Schists of Ireland, by Ch. Callaway, D.Sc., M.A., F.G.S.—The author gives a summary of results obtained by a preliminary survey of the principal areas of Irish metamorphic rocks in Donegal, Connemara, and the south-eastern corner of the county of Wexford. In each of these areas the following facts were observed:—(*a*) A series of hypometamorphic rocks, consisting typically of fine-grained schists, altered grits, and quartzites. A clastic structure is more or less distinct in the three areas, but is least evident in Connemara. (*b*) A group of highly crystalline schists, displaying no trace of an original sedimentary origin, dipping as if it passed below the hypometamorphic rocks. At Wexford there are true gneisses. In Connemara the rocks are less feldspathic, the chief types being quartzose gneiss, quartz-schist, mica-schist, hornblende-schist, quartzite, and crystalline limestone. This description will also apply to Donegal. (*c*) Granite, underlying (*b*), and in Connemara and Donegal clearly intrusive. The author urges that this analogy is not due to the metamorphic action of the granite; for—(1) The mineral characters apparent in the schists adjacent to the granite are uniformly distributed through the lower series from bottom to top. (2) The evidence collected is hostile to the view that this lower series ever graduates into the upper. It is concluded that the balance of proof is in favour of the Archæan age of the bulk of the Irish schists. (1) In the Wexford district the schists are thrown against Cambrian and Ordovician rocks by faults, and do not pass into them in the localities alleged by the Irish Survey. (2) In Connemara conglomerates of Llandovery age contain large rounded fragments, not only of the older schistose series, but also of its intrusive igneous rocks. (3) In the Ulster region the metamorphic area is separated from the Ordovician rocks of Pomeroy by a ridge of granite and diorite three miles in breadth. The lithological analogies between the Irish schists and the Archæan rocks of Anglesey and other British metamorphic districts are also of weight in the argument.

SOCIETIES AND ACADEMIES

EDINBURGH

Royal Society, July 19.—The sense of taste, by John B. Haycraft. Sensation or feeling is a result of the operations of the external world upon our sentient bodies. A vibration of light, a sonorous wave, a molecule of sugar or of musk stimulates the appropriate nerve through the mediation of a little sensitive cellule in the eye, the ear, the tongue, or the nose. A motion called a *nerve motion* is then set up, passes to the brain, and if this organ is in a state of activity we are conscious of a feeling or sensation. In the case of sound and light the character of the vibration determines the quality of the sensation produced. Thus, a certain complex vibration of light produces a sensation we call crimson, a certain complex vibration of sound we recognise as coming from a violin-string. Motion is thus transmitted into a nerve motion or impulse, which gives rise to a sensation. Of the thousand qualities of sensation all have a counterpart in the thousand variations of motion outside the body. The physiologist knows little more about the production of the sense of taste than those facts which are the intellectual property of every one. The object of the author of the paper of which this is a short abstract is to show that taste in its method of production is precisely analogous to sight and hearing. The truth of this is indicated by the striking similarity in structure between the end-organs of all the special senses, which are all developed from primitive ectodermic cells, of much simpler form. Spectroscopic investigation has demonstrated, too, that the sapid and odorous molecules vibrate constantly and in a manner characteristic of each substance. We have, then, in the case of taste (and it is hoped subsequently to demonstrate this in the case of smell as well), vibrating matter and a sensitive end-organ, conditions analogous with those present in the other senses. If it can be shown that substances vibrating in the same manner produce the same taste, the analogy will be complete. It has been found by Newlands and others that if the elements be arranged in a series, starting with that metal which has the lowest, and passing up to that which has the highest, atomic weight, a periodic recurrence of chemical and physical properties is observed. Thus lithium, the second in the series, is similar to sodium, the ninth, and potassium, the sixteenth, and so on. This is called the periodic law. The author finds that there is also a periodicity as regards taste production. Thus the chlorides or sulphates of a series of similar elements—called a group of elements by Mendelejeff—have similar tastes. It is curious, however, that the taste changes slightly but uniformly as we pass to the higher members of a group. Thus the chlorides of lithium and sodium are salt, but as you pass to the higher members of the group the taste becomes more saline and very slightly bitter. Now Prof. Carnelley has recently discovered that compounds containing elements of the same group have similar colours, the colour changing, however, uniformly—passing to the red end of the spectrum—as we reach the higher members of a group. Colour is periodic. But this indicates that the elements of the same group are vibrating in a similar way. If the lower member be yellow from absorption of the blue, the next one will have vibrations of nearly the same pitch, being in reality at a somewhat slower rate of vibration, and absorbing rays nearer the red end. Here, then, is the analogy sought for. A group of salts of similar chemical properties have their molecules in a