president, and told them what he had seen, the answer was that they had great doubts about the success of the experiment. It was thought then that the practical place to give technical instruction and teach the application of science to industry was in the workshops. They had now satisfied themselves, however, that whilst they could not dispense with the practical experience of the workshops, there was something that gave value to that experience. Let them take the art of dyeing for example. What was the old system of training in regard to it? The dyer did not then ascertain the properties of the articles with which he had to deal with that skill and accuracy with which the young men of Leeds were ascertaining them to-day. It used to be a bucketful of this, a shovelful of that, and a handful of the other. But the days of the old rule of thumb were numbered; and on standing at the cradle of the Yorkshire College he stood by the grave of the rule of thumb. He had been greatly encouraged this week by his visit to Yorkshire. He came to it somewhat in a state of despondency: not however with reference to elementary instruction, for the people of Yorkshire were doing wonders in that way, and in a few years hence this county would compare favourably in that respect with any part of the globe. But he had been examining recently, not for the first but the tenth time, what was being done on the Continent in the way of technical education. They had opened a good school in Leeds, but they must not flatter themselves. They must not believe that the 25,000*l*. which his friend Mr. Denison had indicated was the sum wanted to complete the work. He had stood in an industrial town of 70,000 inhabitants, in which a single building that had been erected within the past three years solely for teaching science, as applied to industry, had cost 100,000*l*. He had stood in three or four such towns. He had examined technical institutions in France, in Switzerland, and in the south and north and centre of Germany, and all he could say was, that not having examined these institutions critically for five years, he stood amazed and almost aghast at what he beheld. He came home feeling that in the countries he had mentioned they had found the weak place in our armour, and had wounded us in our tender part; but what he had seen in Yorkshire within the last week had given him renewed confidence and courage. He found, in addition to this splendid institution which had been opened to-day, that in the little town of Keighley—a very splendid little place—they were going to spend 5000*l*. in a weaving-school; that the Clothworkers' Company of London were going to assist Bradford also; and he was told that in Huddersfield they had got 15,000*l*. or 16,000*l*.; that they had no longer to teach elementary instruction in their night-classes, but wanted to give scientific and technical instruction to their workmen, and wanted a school for Huddersfield. Yesterday he stood by the grave of an eminent Yorkshireman who had done noble service to the teaching of science in Yorkshire—his friend Mr. Mark Firth. Would they not see that Yorkshire had many as worthy sons as Mr. Firth? Surely he was not the last man that would endow a college for science teaching. There were men, he hoped, within the sound of his voice who would perpetuate their memory, and show some gratitude to the industry that had made them wealthy by endowing another wing of the College like the one they had seen to-day. They must not believe that this was mere amateur work. This was not science teaching merely for the sake of scientific research, for arriving at scientific truth, or for giving intellectual culture. Those nations on the Continent who had produced such magnificent buildings, machinery, and apparatus to conduct this work were not doing so from sentimental reasons. They were not doing it with the object simply of endowing scientific research, or to make great progress in any particular branch of science. Their object was a very prosaic and a very practical one, and very full of self-interest. What they meant was to get industrial strength, which they believed was the real source of the wealth of their nation. The Yorkshire College was founded to supply instruction in those sciences which were applicable to the industrial arts. He might say as the result of his recent observations that France and Germany were conducting as active a competition with each other in this matter of arming for the industrial fight as any of the nations of the Continent of Europe were in their military armaments with a view to any catastrophe in future. But this was not a case in which Englishmen could look on with benevolent neutrality, because after all in this international fight they could not stand aloof, they could not remain neutral, for the blow, whenever it fell, would fall upon them. Rely upon it the success of the Science College of Yorkshire meant the success of Yorkshire itself. They possessed great natural resources for which their Continental neighbours envied them. They had in their immediate neighbourhood, in the mine, the coal and iron; they had in their people great vigour, great energy, and great inventive capacity; and they had also their old prestige. They had amongst them men of great wealth. There was his friend Mr. Denison ready to provide them capital very freely—at a very moderate rate. England, after all, was the great emporium as a depôt market for nearly all the raw material of the world. To London came that Australian wool so many thousana oales of which were exported to their neighbours on the other side of the water, and then came back to them in a finished state for the consumption of their own population. He was speaking from actual knowledge when he said that there was an enormous increase in the manufacture of dressed goods that could be well made in Yorkshire, that could be produced and sold in Yorkshire, and that were yet made abroad, but ought to be made at home. He believed the step they were taking that day in opening the College was the very way to create that employment at home which at present was too much done abroad. It had been said that the country gentlemen ought to assist in this movement. Lord Frederick Cavendish had come from a great and honourable house, and they all rejoiced in the wealth, ability, business capacity, sagacity, and liberality of that house. But what was it that had made these great houses and England wealthy? Was it not the value which had been added to the land by the success of the great manufactures? The success of the great houses of England was bound up in the success of the Yorkshire College and of other colleges like it. Thus to the success of their manufactures they must look for the continued greatness of England in its dealings with nations in the future. Why, they had but the same area of land now as they had when their population was only 10,000,000. They had 25,000,000 of people in England and Wales now, and they were multiplying at a rate which would soon double this number. What was it that was to feed all these people but the success of their manufactures? If they were to hold their own they must not lose a point; they must not neglect a single opportunity; they must not rest content on their old prestige; but they must, as Englishmen, look the difficulty in the face, and, where weakness existed, strengthen themselves, and this weakness was to be found entirely in the question of education, which they had too long neglected. In asking them to drink success to the Yorkshire College, he was asking them practically to drink to themselves. If they wished perfect freedom to carry on this work, he was quite of the opinion of Lord Frederick Cavendish that they must adopt the newest methods—to be untrammelled in their efforts, to carry on the College by themselves, and in that way in which Englishmen had been accustomed to do their work.

THE ROYAL SOCIETY—ADDRESS OF THE PRESIDENT[1]

II.

THE aspect of spectrum analysis has become much complicated by two sets of facts. First, the increased dispersion, the improved definition, the enlarged electrical power at our command, and, above all, the substitution of photography for eye observations, have revealed to us an almost overwhelming array of lines belonging to each substance. And, secondly, the same means have shown that many substances present different spectra when in different molecular states. These complications have led spectroscopists to seek some relief in theories of simplification. Lecoq de Boisbaudran, Stoney, Soret, and others have suggested that many of the lines, or groups of lines, may be regarded as the harmonics of a fundamental vibration; and they have shown that in certain cases this view will account for the phenomena observed. Professors Liveing and Dewar have contributed largely to the subject by their observations on the reversed lines. Looking in another direction, Mr. Lockyer considers that in increased temperature we have the means not only of resolving compound bodies into their elements, but even of dissociating bodies hitherto regarded as elementary into still more simple substances. There still remain serious difficulties connected with Mr. Lockyer's views; but it is to be hoped that his indefatigable energy will in some way or other ultimately overcome them.

The outlying parts of the spectrum, beyond the visible range,

[1] Address of William Spottiswoode, D.C.L., LL.D., the President, delivered at the Anniversary Meeting of the Royal Society on Tuesday, November 30, 1880. Continued from p. 114.

must always be a subject of interest; and while MM. Cornu and Mascart, and others, have extended our knowledge of the ultra-violet end, Major Abney has opened out to us a new region beyond the red. Lord Rayleigh and others before him have however proved that there must be a limit at the least refrangible end of the spectrum. Prof. Stokes, long since, noticed the difference in length between the spectrum of the sun and that of the electric arc; and M. Cornu has recently shown by observations at elevated stations that the great rapidity of atmospheric absorption must preclude the hope of any great extension of the solar spectrum toward the more refrangible end.

The striking advances made in electricity during the last few years, and marked by, amongst other things, the inventions of the telephone and the microphone, have been followed by a step not less daring in its conception, nor less successful in its execution; I allude, of course, to the photophone, the result of the researches of Mr. Graham Bell and Mr. Sumner Tainter. The principle of this instrument is already known. A powerful beam of light is first thrown upon a flexible mirror, the curvature of which is modified through vibrations set up in it by the human voice. The reflected beam is then received by a selenium "cell" forming part of an electric circuit. The intensity of the light so received, and with it the resistance in the circuit due to the selenium, varies with the varying curvature of the flexible mirror. A large parabolic mirror is used at the distant station to concentrate the light on the selenium "cell"; and a telephone in the circuit reproduces the variations in the form of sound.

Mr. Bell has however also shown that rays from the sun, or an electric lamp, when rendered intermittent by any convenient means, will set up in a plate of almost any substance vibrations corresponding to the intermittence. The substances as yet tried are: metals of various kinds, wood, india-rubber, ebonite, &c., and among them zinc appears to be one of the best suited for the purpose. This result, which is independent of any electric action, is perhaps due to heat rather than to light.

In these, as in many other issues of scientific research, we can hardly fail to be impressed by the almost inexhaustible resources which lie ready to hand, if we only knew how to use them, for the interpretation of nature or for the practical purposes of mankind.

During the past year Prof. Hughes employed his induction balance for the detection of very minute impurities in small masses of gold. Mr. Preece also has shown how slight increments of temperature in fine wires transmitting telephonic currents of electricity will suffice to reproduce sonorous vibrations, and even articulate speech, at a distant station by their influence on thin platinum wires only six inches in length.

Mr. Stroh has shown that, at the point of contact of two metals carrying strong electric currents, adhesion takes place, varying with the nature of the surfaces in contact; and that many of the effects at points of contact, previously attributed to induction, may be due to the peculiar action now for the first time brought under notice.

It is worthy of record that two Atlantic cables have been successfully laid during the present year; but that the operation has become so much a matter of course, that its occurrence has attracted little public attention. Two cables, each of more than 500 miles in length, have been laid across the Mediterranean; and the Cape Colony has been placed in telegraphic communication with this country by a cable of not less than 4400 miles.

Constant attention is paid in the General Post Office to the introduction of improved methods for the furtherance of the telegraphic communication throughout the country.

Steady progress has been made in bringing the electric light into practical use. The illumination of the Albert Dock of the London and St. Katherine's Dock Company, the Liverpool Street Station of the Great Eastern Railway, the St. Enoch's Station of the Glasgow and South-Western Railway, and last, but not least, that of the reading-room of the British Museum, have become accomplished facts; while the City authorities have decided to extend the use of this light over various thoroughfares under their control. The subdivision of the light for domestic purposes is a problem which appears to have found a solution in the incandescent carbon lamp of Mr. Swan. Besides this, Mr. J. H. Gordon has devised, for the same purpose, a very ingenious application of rapid sparks from alternating machines, such as that of De Méritens, to produce incandescence in refractory metals. Lamps constructed on this principle completely fulfil the conditions of subdivision, but some difficulties of detail still retard their adoption for general use. There is, however, every reason to hope that the experience already gained, and the intelligence at present brought to bear upon it, will before long supply us with more than one form of domestic light.

The chief question of interest which has occupied the attention of the Iron and Steel Institute has been the adaptation of the "basic" process to the production of steel from pig metal containing a considerable percentage of phosphorus. Hitherto only pure hæmatite and spathic ironstones have been used for the production of steel; but it has now been shown that, by the employment of basic linings and basic slags, the metal is almost completely cleared of its phosphorus, and that steel of good quality may be produced from inferior ore.

The Conference on Lightning-Conductors, composed of delegates from the Royal Institute of British Architects, the Society of Telegraph Engineers, the Physical Society, and the Meteorological Council, is steadily pursuing its labours. A large mass of facts has been accumulated; several leading questions have been decided; and it is hoped that, in the course of the coming year, the Report of the Conference will be issued.

One of the most interesting, and at the same time useful, applications of the dynamo-machines, is that of transmitting mechanical power to spots, or under circumstances, where the ordinary appliances cannot be conveniently used. Their principle will doubtless by degrees extend itself over a wide range of industry; especially in localities where water-power is abundant. A very remarkable instance of such adaptations will be found in Dr. Werner Siemens's propulsion of railway carriages in Berlin.

Our Fellow, Dr. C. W. Siemens in London, and M. De Méritens in Paris, have demonstrated the use of the high temperature of the electric arc in fusing refractory metals. The method of operation, while peculiarly convenient for laboratory purposes, and for demonstration, promises to be capable of extension, even to the large demands of commerce and manufacture.

I should not, moreover, omit mention of the very beautiful experiments by Dr. C. W. Siemens on the effect of the electric light on the growth of plants, on the opening of flowers, and on the ripening of fruit. On this subject we hope to hear more hereafter. He has already commenced a fresh series of experiments, and contemplates continuing them during the coming winter.

I am not sure how far the fact is known to the Fellows of the Royal Society that the Society of Telegraph Engineers has thrown open to the scientific world a remarkable collection of books on electrical science, collected by our late Fellow, Sir Francis Ronalds, and bequeathed by him to that Society. The catalogue, compiled by the collector, is a monument of concentrated and well-directed labour.

As regards the Transit of Venus in 1874, the printing of the observations is complete for the two groups of stations in the Sandwich Islands and Egypt, and that for others is in progress.

Preparations are already being made with a view to the observation of the Transit of Venus in 1882. As a preliminary step for this operation, as well as for general purposes, it had been decided that the longitude of the Cape Observatory should be definitively determined by telegraphic connection with Aden, which place is already telegraphically referred to Greenwich; and, notwithstanding a temporary interruption on the land line, Capetown-Durban, it may be hoped that the connection will be effected at no distant period. Mr. Gill is prepared to undertake the main share of the work. With the same objects in view, on the urgent representation of the Astronomer-Royal, it has also been determined to connect one of the Australian Observatories with Greenwich, through Madras, the longitude of which is well known; and this operation will be very much facilitated by the share which Mr. Todd, Government Astronomer and Superintendent of Telegraphs at Adelaide, would be prepared to take in it under the auspices of his Government. The eastern boundary of the Colony having been defined by Imperial Act as the 141st meridian, a wish has been expressed officially for the accurate connection of Adelaide with Greenwich, independently of the Transit of Venus.

The Astronomer-Royal has explained in detail the preparations which he considers necessary, so far at least as this country is concerned, for the effective observation of the transit, and he has introduced several alterations in the plan which he had formerly suggested. The experience of the transit of 1874 points to the desirability of sacrificing something in the magnitude of the parallax-factor for the sake of securing a higher elevation of the sun; thus, for retarded ingress, Sir George Airy had at first proposed to refer principally to the coasts of the Canadian Dominion and the United States of North America, where the sun's elevation is from 15° to 18°; he now proposes to substitute for this the whole chain of West India Islands, from the eastern extremity of Cuba to Barbadoes, or stations on the neighbouring continent of Central America. Bermuda is also included as a favourable point for observation. Most, if not all, of the longitudes required have been determined with great precision by the Hydrographic Department of the United States. For ingress accelerated, Sir George Airy relies entirely upon stations in the Cape Colony. For the accelerated egress, all the stations suggested for ingress retarded will be available. For egress retarded, although the fixed Observatories at Melbourne and Sydney will contribute to the observation of the phenomenon, they will have the sun at a somewhat low elevation (10—14°); it is thereby proposed to rely mainly upon New Zealand, with which we are in telegraphic communication *viâ* Sydney. Considerable correspondence has taken place on the subject of Australian longitude, and it is expected that the necessary steps to effect the connection of one of the Observatories, probably Adelaide, with Madras, will be taken early in the ensuing year.

Sir G. B. Airy has completed the laborious calculations in his Numerical Lunar Theory, from which the corrections to the coefficients of Delaunay's Lunar Theory are to be deduced; and in connection with this work he has made an investigation of the value of the Moon's Secular Acceleration, for which he finally obtained the value 5″·477, thus confirming the results obtained by Prof. Adams, and subsequently by Mr. Delaunay. On this important question, Prof. Adams has also published an investigation (*Monthly Notices*, vol. xl. Nos. 6, 7, 8 and 9).

A new determination of the Physical Libration of the Moon from a large number of lunar photographs taken with the De La Rue reflector at the Oxford University Observatory has been recently made by Prof. Pritchard, the result being to indicate the existence of a small rotational inequality.

Messrs. J. Campbell and Neison have made use of the Greenwich Observations, 1862 to 1876, to determine the Lunar Parallactic Inequality, from which they deduce for the value of the Solar Parallax, 8″·778, or 8″·848, according as the existence of a forty-five year inequality, apparently indicated by the observations, is admitted or not (*Monthly Notices*, vol. xl. Nos. 7 and 8). The Sun's Parallax has also been determined by Mr. Downing, from N.P.D. observations of Mars at Leyden and Melbourne, in 1877. The value thus found is 8″·96 (*Astronomische Nachrichten*, No. 2288).

In continuation of his researches on tidal retardation from the action of a satellite on a viscous planet, Mr. G. H. Darwin has investigated the secular changes in the orbit of a satellite, deducing the early history of the earth and moon from the time when they were initially in contact, each revolving in the same period of from two to four hours. This leads to the suggestion that the moon was produced by the rupture of the primæval planet. In another memoir, Mr. G. H. Darwin gives analytical expressions for the history of a planet and a single satellite. (*Phil. Trans.*, 1879, *Proc.* Roy. Soc., Nos. 200 and 202.)

An important work in connexion with the United States Northern Boundary Commission has been published by Mr. Lewis Boss, on the Declination of Fixed Stars. The systematic corrections to some seventy catalogues have been discussed, and, from the mean of the whole, standard declinations of 500 stars have been deduced.

Dr. Gould's "Uranometria Argentina" and M. Houzeau's "Uranométrie Générale," are of especial value as giving important information on the brightness and distribution of the stars in the southern hemisphere.

Interesting results as to the diameters of satellites have been obtained by Prof. Pickering from photometric observations, on the assumption that their albedos do not differ greatly from those of their respective primaries. (*Annals*, Harvard College Observatory, vol. xi.) He has further investigated, on somewhat similar principles, the dimensions of the fixed stars, with especial reference to binaries and variables of the Algol type. (*Proc.* Amer. Acad., vol. xvi.) Prof. Pickering has also commenced a photometric survey of the heavens, in which the brightness of every star visible to the naked eye is to be determined. He has further undertaken a search for planetary nebulæ by a new method, in which, by the use of a direct-vision prism in front of the eyepiece, the nebula is at once detected by its monochromatic spectrum, focussing a point of light instead of a coloured line as in the case of a star. About a hundred thousand stars have been examined, and four new planetary nebulæ have been detected. (*American Journal of Science*, October, 1880.)

From the grouping of the aphelia of certain periodic comets Prof. G. Forbes has inferred the existence of two ultra-Neptunian planets, and has indicated their approximate positions. (*Trans.* Roy. Soc., Edinburgh.) Mr. D. P. Todd has deduced from the perturbation of Uranus a position for an ultra-Neptunian planet closely agreeing with that found by Prof. G. Forbes. So far, the search for the hypothetical planet with the 26-inch Washington refractor has been unsuccessful. (*American Journal of Science*, September, 1880.)

Prof. Bredichin's researches on the tails of comets have led him to the classification of these appendages according to the value of the solar repulsive force which would have generated them. Having discussed the forms of the tails of thirty-three comets, he finds that they belong to three types, corresponding respectively to repulsive forces 11, 1·4 and 0·3 (the sun's gravitation being taken as 1); and adopting Zöllner's hypothesis of a repulsive force, due to electricity and inversely proportional to the specific gravity, he infers that the tails of the three types are composed respectively of hydrogen, carbon, and iron. In the case of the second and third types other elements of nearly the same atomic weight may replace or be mixed with the carbon and iron, and in such a comet as Donati's a number of substances may be mixed in the tail, which will consequently spread out in the plane of the orbit. The first type composed of hydrogen will always remain separated from the others. (*Annales* de l'Observatoire de Moscou, vols. iii-vi.)

The appearance, at the beginning of this year, of a great comet in the southern hemisphere, recalling by the length of its tail and the smallness of its head the remarkable comet of 1843, has excited great interest, more especially as it was found that the orbits of the two comets were sensibly the same. The observations of the comet of 1843, however, do not appear to be compatible with so short a period as thirty-seven years, and Prof. Oppolzer has shown that the action of a resisting medium would not meet the case. (*Astronomische Nachrichten*, Nos. 2314, 2315.) Under these circumstances Prof. D. Kirkwood has suggested that the two bodies may be fragments of one original comet, viz., that of 370 B.C., which is said to have separated into two parts like Biela's comet (*Observatory*, No. 43.) Five other comets (including Faye's periodical comet) have been discovered this year, but two of them were lost through cloudy weather before a second observation could be obtained.

In astronomical physics Mr. Huggins has obtained photographs of stellar spectra, which establish the existence of a remarkable group of nine bands in the ultra-violet, probably due to hydrogen, and further lead him to an arrangement of the stars in a continuous series according to the breadth and marginal difference of the typical lines, particularly of the K line. Mr. Lockyer continues his researches on dissociation, as indicated in solar outbursts, and in connection with this work is engaged on a systematic observation of the spectra of sun-spots. At the request of the Committee on Solar Physics, corresponding observations are being made at Greenwich.

From the series of Greenwich photographs of the sun, 1874—1879, the mean heliographic latitude of spots and mean distance from the sun's equator, have been deduced for each rotation and for each year ("Greenwich Spectroscopic and Photographic Results," 1879).

A fine 36-inch silver-on-glass reflector has been recently constructed by Mr. Common, and with this instrument he has obtained photographs of Jupiter, showing the red spot, and of the satellites (*Observatory*, No. 34).

At the outset of an undertaking one figures to oneself in imagination what may be done; towards the close of it one sees in actual fact what has been done. In commencing this address I had hoped to say something of the progress of mathematics; before bringing it to a conclusion I find my space filled and my time exhausted. How far the good intentions of this year may be realised in the next, cannot yet be seen; but the difficulties of a task do not always diminish the fascination of making an attempt.