OBITUARY NOTICES

OF

FELLOWS DECEASED.

CONTENTS.

	Page
William Edward Ayrton	i
Bindon Blood Stoney	viii
Friedrich Wilhelm Kohlrausch	xi
Sir Charles Todd, K.C.M.G.	xiii
Greville Williams	xvii

WILLIAM EDWARD AYRTON, 1847—1908.

Prof. Ayrton was born in London on September 14, 1847, and he died November 8, 1908. He was elected to the Royal Society in 1881, and he was awarded a Royal Medal in 1901.

He was the son of an able barrister, Edward Nugent Ayrton, and the nephew of the Right Hon. Acton Ayrton, who was a member of Mr. Gladstone's Government from 1869 to 1874. He belonged to a family which for three hundred years had been represented by lawyers, musicians, surgeons, clergymen, university dons, and schoolmasters. He distinguished himself at University College School, and later at the College; he gained the Andrews Exhibition in 1865, and the Andrews Scholarship in 1866. In 1867 he passed with honours the first B.A. examination in the University of London; in the same year he came out first in the examination for the Indian Government Telegraph Service, and in preparation for India he became a pupil of Lord Kelvin in Glasgow. In India, after acting as assistant to Mr. Schwendler, he succeeded him as Electrical Superintendent of the Telegraph Department; these two men revolutionised the Indian telegraph system. In 1872–73 he was on special duty in England, and assisted Lord Kelvin and Prof. Jenkin, the engineers for the Great Western Telegraph Cable. From 1873 to 1878 he was Professor of Natural Philosophy and Instructor in Telegraphy in the Imperial College of Engineering, Tokio, Japan. From 1879 to 1884 he was Professor of Applied Physics at the City and Guilds Technical College, Finsbury, and at the same time he had much practice as an engineer. From 1884 till he died he was Professor of Applied Physics and Electrical Engineering at the City Guilds Central Technical College, Kensington. An active member of the Institution of Electrical Engineers almost from the beginning, a diligent member of Council and of the Committees of the Council, he became President in 1892. He was President of the Physical Society of London in 1890 and 1891, and President of Section A of the British Association in 1898. He served on Juries at various exhibitions, and as a member of various Congresses dealing with international electrical questions.

A complete list of his scientific papers will be found published in the memorial number of 'The Central' (the Journal of the City Guilds Central Technical College) for April, 1910. Eleven of these were published by him before 1876; sixty-eight in partnership with Prof. Perry between 1876 and 1889; during this interval there were also sixteen in his own name or occasionally in partnership with other workers; after 1889 he published fifty-one papers, many of them in partnership with Prof. Mather, Dr. Sumpner, and others. He was joint editor with Dr. Wormell of a series of Manuals of Technology in 1881, and he wrote one of these Manuals on 'Electric Lighting and Transmission of Power.' Later this book, greatly altered and added to, took the new title 'Practical Electricity.'

His work previous to 1874 lay in improving telegraphic methods, especially those employed in India. During his first year in Japan he arranged an electrical laboratory, which was certainly the finest then existing in the world. A description of it will be found in a paper read before the Society of Arts in 1880 by Prof. Perry. Even in 1874 he was carrying out the idea that not merely for a few students, but for all of his students, laboratory work was the essential thing, and that lectures and numerical exercise work were the auxiliary things in a scientific education.

His students were very earnest and hardworking, and they became enthusiastic about laboratory work, especially in electricity. Prof. Ayrton was himself intensely fond of experimental work in electricity; he used often to work throughout the night and throughout the long and very hot or cold holiday time in Japan. Readers must remember how very different things were from 1874 to 1878 from what they are now. At the forty-one consecutive meetings of the Royal Society from December 11, 1873, to May 13, 1875, there were in all only five papers read which had a bearing on electricity; indeed, there were not many electrical experimenters in the world, and the Japanese investigations from 1875 to 1878, published in numerous papers read before the Royal Society, the Physical Society, the Institution of Electrical Engineers, and elsewhere, attracted a great amount of attention not only from scientific people, but from many other persons whose imaginations were beginning to be stirred by the importance of the telephone, the dynamo machine, and the electric light.

After his return to England, Prof. Ayrton arranged an electrical laboratory at the Finsbury Technical College, intended for evening students who were workers in electrical engineering industries, and also intended for large classes of day students. This laboratory and his methods have been copied by hundreds of Polytechnics and technical schools, and it is well here to state precisely in what way he made a new departure. Long before he went to Japan, some of the students attending Physics lectures in many parts of Great Britain had been doing laboratory work, but in every case these students were very clever volunteers. Ayrton gave interesting laboratory work to *all* his students. The motors and dynamos and other contrivances which were tested were not so small as to be toys, and they were not so large but that they could be left in charge of the average student without fear of disaster. But it was the preliminary work that was particularly his invention. In the study of mechanics and other parts of physics we deal with weight, inertia, stress, colour, space, etc., and his senses make such things tangible to a student; but in electricity we deal with something almost abstract, and there must be a regular training which will make the things which we call current and voltage and resistance and magnetic induction just as tangible to the student as weight is. Such laboratory practice as had hitherto existed was for the clever student. Prof. Ayrton recognised that the *average* student usually learnt nothing whatever, because there was usually no attempt to make these ideas familiar to him. Hence he not only insisted on giving laboratory work to every student, but determined that the object of much of the work should be to familiarise the student with the most elementary notions. Thirty years have elapsed, and many of the teachers who use apparatus and laboratory arrangements copied from Finsbury are not yet aware of the futility of trying to teach the average student through unfamiliar abstract ideas. All throughout his life, Prof. Ayrton was afraid of talking over the heads of his hearers, of assuming that because an idea was familiar to himself, it was therefore familiar to them.

Again he never tried to produce the perfect engineer. He aimed at creating a learner, a person of developed common sense, a man who would learn engineering when he had the chance of practice, a man whose education would go on till he died; a man who could use books, a man fond of reading. It is difficult to say how much of his system is due to his colleagues at Finsbury. They had the same ideas, they never quarrelled, they never seemed to differ in opinion; on any given question they seemed always to come to the same conclusions. No mere chemist taught chemistry, no mere mathematician taught mathematics, no mere physicist taught physics, no mere specialist taught anything at that college. Every subject was taught through the other subjects. There was no examination from the outside and there was no pretence of preparing men for examinations. No marks were given for lecture notes; but rough laboratory notes and finished accounts of laboratory work in good English, with elaborate sketches and squared paper curves, were thought most important. As hundreds of students passed through laboratories of no large dimensions in one week, and as the number of instructors was very limited, it was impossible on any system whatsoever to give instruction which satisfied the Professor; but at any rate the average student really did learn something and was eager to work, and it was found possible to give great encouragement to any student who adventured and discovered things of which he had not been told. Advanced students had fine opportunities for original research. In dealing with students, that earnestness and enthusiasm and inspiration, that training in scientific method, that sympathy and helpfulness for others which Ayrton received from Lord Kelvin, he handed on to many thousands of pupils, and they in turn are handing them on to new generations.

In 1884, when he became Professor at the Central College in Kensington, he, for the third time, arranged an electrical laboratory. The money available being as great as what he had in Japan, his own experience being much greater and quite different, and the position of the study of electricity being recognised as having become one of enormous importance by the industrial world, it became what it now remains—a most perfect laboratory. There are in existence laboratories with larger and much more expensive equipment, but size and cost in a college laboratory are poor things in comparison with fitness for educational purposes.

Till 1884 and later Prof. Ayrton was not only the most important teacher of applied electricity, he was one of the very few great pioneers in the development of electrical engineering; his students knew that they listened to a man whose days and nights were filled with success in invention and discovery. There are now hundreds of good schools of electrical science; in most of them Ayrton's pupils are teaching. There are now thousands of electrical engineers in whose employment a man can obtain experience. But before 1884 there was only one school, there was almost only one office in which, and there was almost only one engineer in whose service, education and experience could be found. Many young men of promise were attracted from Germany and America and elsewhere to the place where new discoveries and new inventions were the order of the day. Those discoveries are now such common knowledge, those inventions are such usual parts of all electrical machinery, that nobody dreams of mentioning their author's name in connection with them.

He not only read papers at The Institution of Electrical Engineers, but he looked after the interests of that Society with the care of a parent. His contributions to numerous discussions were always well prepared and ought to be read by all who are interested in the history of electrical engineering.

He was particularly successful as a public lecturer—first, because he never lectured on worn-out subjects, but on those which had been greatly developed by himself, and were of great popular interest; second, because he had made a study of elocution, and he had cultivated a particularly good voice; and thirdly, because he spared no pains in preparing his addresses, and in arranging his experiments. But, indeed, all his work was thorough; he was not only a man of large ideas, he was also a man who was a master of detail and who worked hard continuously, so that his success was well earned.

Of the numerous investigations in Japan the most important were on the potential differences between substances in contact; the properties of dielectrics, and particularly their behaviour as electrolytes; heat conductivity in stone; the explanation of the "magic" properties of certain Japanese mirrors; the measurement of v, the ratio of the electro-magnetic to the electro-static unit of electric quantity; the theory of continuous beams, &c. Work on some of these subjects was continued in England, but till 1886 most of the publications relate to inventions of instruments such as sets of permanent magnet and other instruments to measure electric current and voltage, self and mutual induction, etc. The most important inventions were the clock and motor methods of metering the supply of electricity to houses, and these methods are almost the only ones now in use. There were also improvements in dynamo machines, and especially in electromotors; a dispersion photometer; spring balances; resistances for use with strong currents, varied by foot and hand; the power-meter; ohmmeter; a non-sparking key; switches for use with accumulators and arrangements for lighting railway trains; photometers; dynamometer couplings and transmission and absorption dynamometers; an electric arc lamp; the governing and regulation of motors and dynamos; an electric tricycle; an electric railway system with friction gearing, contact boxes, locomotives and automatic blocking, forming part of the general telpherage system; seeing by electricity; a multi-reflex arrangement for measuring the angular motion of a mirror; a ballistic galvanometer, &c. Two very important inventions were a magnifying spring and a twisted strip. Many of these inventions were described in papers read before scientific societies; many of them are in general use now in electrical engineering. Many papers published till 1889 describe investigations on the electric arc; the most economical potential difference to use with lamps, economy in electrical conductors, the expansion of mercury between 0° C. and −39° C., efficiency of lamps with direct and alternating current, the efficiency of transformers, the practical unit of induction, the study of accumulators, photometry, the index of refraction of ebonite, measurement of the ohm, the economical use of gas engines, the distribution of electric energy, electric railways, the electric resistance of liquids, the theory of beams fixed at the ends, the driving of dynamos with short belts, the magnetic circuit of dynamos.

From 1890 until his death his inventions had less to do with practical engineering; a new quadrant electrometer, the credit in which is shared with Dr. Sumpner; numerous instruments used in his new laboratory; a variable inductance standard; the Ayrton-Mather galvanometer; a magnetic field tester; a universal shunt; transparent conducting screens; air choking coils; a new current weigher, the credit of which was shared with the late Prof. Viriamu Jones, and many other inventions.

Papers were published describing these and other laboratory instruments, as well as investigations: thermal emissivity of thin wires in air, measurement of electric power, on glow lamps, non-inductive resistances, efficiency of transformers, the electric arc, speed and voltage in electric motors, submarine telegraphy, the ohm, sensibility of galvanometers, permanency of resistance coils, on smell, dielectric hysteresis, the cadmium cell, etc. He contributed five important articles to the Engineering Supplement of 'The Times.' He published many papers and addresses on educational subjects.

In all his laboratory work at Finsbury and Kensington he greatly relied upon the collaboration of Mr. Mather, who is now his successor, and he was always ready to declare his gratitude for the assistance of that very gifted man.

The most active time of Prof. Ayrton's life was that in which he was one of the very few men who were developing electrical engineering. Later, when there were many men creating new electrical industries, he saw that his best work lay in the improvement of laboratory methods and instruments, and particularly in the education of his students. Perhaps it is wrong to say that he was less active than before. In the memorial number of 'The Central,' above mentioned, some of his pupils tell of the enthusiasm which he created. Even the average student was lifted out of his petty life of care about examinations, and saw that there was a higher life, and not only this, but his methods of observing and working and thinking became truly scientific. As for the exceptionally clever students they received an inspiration which is placing them higher and higher among scientific workers. As Mr. Maurice Solomon has said, the first few weeks of Prof. Ayrton's teaching came as a revelation to students, for "the nightmare of the text-book and the methods of the crammer vanished into the limbo of the past."

Mr. Solomon proceeds:—"Though lectures and exercise classes necessarily supplemented the work of the laboratory, they were based as far as possible on the laboratory work, and the student was always made to feel that it was the experience which he was gaining in experimental work which would be of value to him in after life, rather than the actual knowledge of facts which he was acquiring. And to this end also may be traced the far greater importance attached to the reports on experiments than to the transcript of lecture notes or the working out of mathematical examples. On the reports drawn up by the senior students on their research work, Prof. Ayrton brought to bear the whole weight of a strong critical faculty, and there must be many of his students who recollect, possibly with mixed feelings, the care and thoroughness with which he would examine their accounts of their researches. For those who were fortunate enough to have been engaged on some piece of valuable original research no trouble was too great; each argument was examined step by step, each method was examined step by step, each method was discussed from all sides to make certain that no flaw could be discovered in the structure, and that no loop-hole for error existed. The papers which have been published by his students, both during and after their College days, bear eloquent testimony to the thoroughness of these methods. And the files of the College contain as much unpublished work of a similar character and of almost equal value, work that remains unpublished because the men have been wanting to carry to their conclusion the researches of their predecessors, or because it has been laid aside on account of 'so many other interesting things to attend to.'

"Much of the spirit which permeated the teaching at the College was due to the principles on which that teaching was based, principles which have since been extended to other institutions and other subjects. But much also was due to the personalities of the exponents. Prof. Ayrton deserves truly to rank as a teacher of the first water: it is a quality only to be judged by the effect upon the students. As a great headmaster moulds by almost imperceptible influences the characters of those who pass through his school, so that his reputation lives and survives, not because of some thing or things that he has done and that can be recorded, but in the tradition that passes down the generations of his pupils, so did Prof. Ayrton influence and mould his students. He was able to impart to them some at least of his own enthusiasm for his subject, and to awaken any powers that were latent to their full development and fruition. 'If you would gauge the full effect of Prof. Ayrton's work you must not look to the record of the distinguished positions he has held, to the list of his inventions, or the tale of his publications; you must not look even to the positions which are held by those who have been his students; you must look rather to the methods in every electrical factory or undertaking in which his students have played a part, and there you will find that in a greater or lesser degree according as the instrument was more or less worthy, his teaching has had its influence, and that some part of the success and prosperity is due to him. Whether for laying many of the foundations on which it has been built, or for providing a supply of rightly trained, capable, and enthusiastic builders, there are few men to whom the electrical industry of to-day owes a greater debt of gratitude than to Prof. Ayrton."

In the same memorial number we find the following:—

"Abundant initiative was another prominent feature of his character, and his influence on colleagues, assistants, and students in this direction was very marked. He had the gift of interesting those about him in original work, and of inducing them, both by example and precept, to follow such work to a successful issue.

"Unlike some investigators, Prof. Ayrton was always anxious that his assistants and students should participate in the credit resulting from any research in which they had taken part, and this accounts in a great measure for the large number of joint papers for which he was mainly responsible.

"To be associated with him in a piece of original work, or in a patent case or Parliamentary inquiry, was indeed an education in itself, for the logical and methodical manner in which the subject was considered in all its bearings, and the thorough and painstaking way in which the results or evidence were criticised and checked before being accepted, was remarkable. No amount of trouble was too great for him to take to ensure accuracy, and things which to others might appear trivial were fully examined in detail, for to him thoroughness was an essential factor in everything.

"As a chief he was ever thoughtful and considerate for his subordinates, but at the same time expected whole-hearted work from each and all. Never sparing of himself and always willing and eager to assist and encourage others in any work they were engaged, he took a particular pleasure in helping others to help themselves.

"Independence of thought and action always commanded his interest and appreciation, whilst unreasoning imitation was severely criticised on many occasions.

"The encouragement of his pupils to think for themselves and to examine critically the statements of even recognised authorities were cardinal features of his teaching, and 'to follow the crowd' in any matter was foreign to his nature."

He married his cousin, Matilda Chaplin, one of the famous Edinburgh medical students who may be said to have been the martyrs in the cause of women's higher education. She was energetic, artistic, literary and scientific, and they were sympathetic partners. She studied in Dublin and became a licentiate of the Royal College of Physicians. She studied in Paris and took her M.D. degree in 1879, her thesis being an account of elaborate scientific work done by her in Japan. Their daughter, Edith, now Mrs. Israel Zangwill the writer, was born in Japan. His second wife was Miss Marks, a distinguished Girton student; she was awarded the Hughes Medal of the Royal Society in 1906 for her long continued experimental investigation of the electric arc and her work on sand ripples. Their daughter, Barbara Bodichon, now Mrs. Gould, is distinguished as a public speaker.

J. P.

BINDON BLOOD STONEY, 1828—1909.

Bindon Blood Stoney was born at Oakley Park, King's County, on June 13, 1828. He was the second son of George Stoney, B.A., of Oakley Park, in the King's County, and of Anne, second surviving daughter of Bindon Blood, D.L., of Cranagher and Rockforest, in the County Clare.

In the University of Dublin he graduated in Arts and Engineering. In the Faculty of Arts he was distinguished as a mathematician; and in Engineering he was the foremost man of his class, and won, without a single exception, the first of every distinction then conferred in that Faculty.

Family affairs having rendered it difficult, if not impossible, for him to follow up his University course in the usual manner by serving a term of apprenticeship to some distinguished engineer, he commenced work by taking the place of his brother, George Johnstone Stoney, at the Observatory of Lord Rosse at Parsonstown, where he made his mark by the excellence of the astronomical work he accomplished, and especially by making more accurate delineations of nebulæ than had before been obtained, and which continued to be among the best until, at a subsequent period, all eye observations were superseded by photography.

One of his achievements was ascertaining by eye observations the spiral character of the great Nebula in Andromeda, a discovery which he made in the early fifties of the last century, long before the days of astronomical photography. His work under Lord Rosse and another small employment occupied his time until he obtained, under Mr. Greene, his first professional engagement in laying out railways in Spain. There Mr. Bindon Stoney laid out one of the main lines.

He successively held the following appointments: Assistant Engineer on surveys for Spanish railways, 1852—1853; Resident Engineer on the Boyne Viaduct, 1854—1855; Assistant Engineer, Port of Dublin, 1856; Executive

Engineer, 1859; and Engineer-in-Chief, 1862, which last appointment he held until 1898, when he retired after forty-two and a-half years' service.

When appointed as Assistant Engineer to Mr. James Barton on the Boyne River Viaduct he brought to bear on his work the scientific training he had received at Trinity College, Dublin, one of the first Universities to establish a School of Engineering. That structure, the Boyne Viaduct, was the first of its kind in which, upon a large scale, the strength of each part was accurately proportioned to the stress it had to withstand; thus saving material and, by reducing the weight, avoiding all the useless stresses which are prominently and mischievously present in all earlier viaducts. The safety of the structure was increased, as well as the length of span over which it could be erected.

It is reasonable to assume that his connection with the Boyne Viaduct led up to the writing of his classical work on the "Theory of Stresses in Girders and Similar Structures," which in its time was an epoch-making work, and went through many editions at home and in America, and with which his name will ever be associated.

He was appointed Assistant Engineer to the Port of Dublin in 1856, and in 1859 was called upon to act as Executive Engineer; in 1862 he was appointed Engineer-in-Chief, and it was in this position that his brilliant constructive powers were exhibited to the best advantage.

The Port of Dublin at that time was a tidal harbour with a shallow approach channel from the Bay to the city. In dredging out this channel he broke away from precedent and designed a large dredging plant, including harbour barges of the capacity of 1000 tons for conveying the dredging material out to sea. The economy thus effected allowed the Port Board to press forward the improvement of the approach to the Port of Dublin, so that at the completion of his work it was no longer a tidal port but open at all states of the tide to vessels engaged in the cross-channel and coasting trades, which form by far the larger portion of the total trade of the Port of Dublin.

He rebuilt a length of 6825 feet of quay walls, equal to half the shipping quays of the port, and replaced the tidal berths by deep-water berths at which large over-sea vessels could lie floating at all tides. The northern quays were extended eastward and the Alexandra Basin begun. To avoid the necessity of costly coffer dams and pumping, he built the lower portion of these quay walls with concrete masonry blocks of 350 tons weight. The blocks were of such a size that when one end rested on the bottom, the other reached low-water level, so that the masonry that had to be added was all of it subaerial work. The immense blocks were unlike ordinary concrete. They consisted, for the most part, of irregular masses of rock of great size, so placed that they touched one another at but few points, and were everywhere else firmly bound together, and to the rest of the structure, by fine concrete poured in between them. A special machine for making the fine concrete was designed by Mr. Stoney, which has since come into general use wherever large quantities of concrete are required.

The blocks were built on a platform, and when sufficiently hardened were lifted by specially designed floating shears and transported to the site of the new quay. All machinery for handling these blocks, and the gigantic diving bell for laying the foundations, were designed by him, and were fully described in a paper which he contributed to the Institution of Civil Engineers, and for which he received the Telford Medal and Premium.

Among the many other works carried out by Mr. Stoney, the levelling and widening of the bridges over the River Liffey within the City of Dublin may be referred to on account of the special advantage which this work conferred upon the citizens.

A marked characteristic of Mr. Bindon Stoney's work as an engineer was the correctness of his engineering estimates. The actual cost of the work was, in each instance, nearly identical with that which he had been able to compute, thus avoiding the necessity for supplementary estimates. This reliability will be appreciated by all who have had experience of extensive engineering works.

Mr. Stoney retired from the service of the Port of Dublin in 1898, in his seventy-first year, respected for his engineering ability, unswerving integrity, and love of truth and justice, and regretted by all of his staff.

No record of Mr. Bindon Stoney would be adequate without some reference to the remarkable degree in which he was helpful to others throughout his long career, and amongst these to the many engineers whom he encouraged and helped forward in the early stages of their profession.

He was elected a Fellow of the Royal Society in 1881, and also received the honorary degree of LL.D. from the University of Dublin. He was a member of the Royal Irish Academy and of the Royal Dublin Society, and a member of the Institution of Naval Architects. He was elected a member of the Institution of Civil Engineers of Ireland in the year 1857, and for many years took an active part in its management. He contributed the following papers to its 'Transactions':—"Boyne Viaduct Experiments," 1858; "Newcastle Coal Experiments," 1859; "Effects of Salt Water on Lime Mortar," 1862; "Boyne Viaduct Girder Experiments," 1868; "Portland Cement in Marine Works," 1871; President's Address, 1872; "Strength and Properties of Riveted Joints," 1885; "The Most Economical Spans for long Girder Bridges with Numerous Spans of Equal Length," 1905.

He was Joint Honorary Secretary of the Institution of Civil Engineers of Ireland from 1862 to 1870, and was President for the years 1871 and 1872.

Dr. Stoney was elected an Associate of the Institution of Civil Engineers (London) on January 12th, 1858, and was transferred to the class of Members on November 17th, 1863. He was also a Member of the Council for a number of years. The following papers contributed by Dr. Stoney are printed in the 'Proceedings' of the Institution:—"Construction of Floating Beacons"; "Construction of Harbour and Marine Works with Artificial Blocks of Large Size"; "Description of a New Balance Bridge over the Royal Canal at Dublin."

H. G.

FRIEDRICH WILHELM KOHLRAUSCH, 1840—1910.*

FRIEDRICH WILHELM KOHLRAUSCH was born in October, 1840, at Rinteln-on-the-Weser. His father, Rudolph Kohlrausch (1809—1858) was a distinguished physicist, who did much work of fundamental importance in clearing up the mutual relations between static electricity and galvanic electricity. He is probably best known for his determination, jointly with Wilhelm Weber, of the ratio of the electromagnetic to the electrostatic unit of electric quantity. The son studied at Erlangen and Göttingen, and took the degree of Ph.D. at Göttingen in 1863. Three years later he was appointed Professor Extraordinarius in the same University. In 1870 he went to Frankfort-on-the-Main as Professor of Physics in the Technische Hochschule, and in about a year he was appointed to a similar professorship in the Gross-Herzogliche Polytechnikum at Darmstadt. In 1875 he became Professor of Physics in the University of Wurzburg, and moved thence to the University of Strassburg in 1888. In 1895 he was appointed President of the Physikalisch-Technische Reichsanstalt at Charlottenburg, and was elected a member of the Academy of Science of Berlin, and also a Foreign Member of the Royal Society of London. He was made honorary Professor of Physics in the University of Berlin in 1900. In 1905 he resigned his post at Charlottenburg. He was elected an honorary Member of the Physical Society of London in 1906. He died at Marburg on January 17, 1910.

Kohlrausch was the author of a great number of papers giving the results of experimental investigations in many branches of physics, but the subjects which chiefly occupied him were the methods of measuring magnetic and electrical quantities. Among his contributions to this branch of science we may mention his method of determining in absolute measure the horizontal component of the earth's magnetic field and the strength of an electric current by observations of the simultaneous deflections of a tangent-galvanometer and of a suspended coil, when both instruments were traversed by the same current, the position of equilibrium of the coil when there was no current through it being such that its axis was horizontal and at right angles to the magnetic meridian.

Another important set of experiments, published in 1874, had for its object the determination of the absolute value of the "Siemens Unit" of electrical resistance. Although the result obtained was afterwards shown to be appreciably in error, this investigation was of historical importance, since it directed attention to the necessity of examining further the values

* Use has been made, by permission, of an article that appeared in 'Nature,' February 3, 1910, vol. 82, p. 402.

obtained in 1863 and 1864 by Maxwell and his coadjutors for the British Association Committee on Electrical Standards.

In 1871 Kohlrausch introduced a method for measuring the electrical resistance of electrolytes, founded on the use of alternating currents, whereby the disturbing effect of the polarisation of the electrodes was almost entirely got rid of, and results were obtained of a far higher degree of accuracy than were attainable by the methods previously in use. In order that polarisation should be eliminated, it was essential that the alternations of the current should be of short period, and that the quantity of the current should be the same in each direction. In order to fulfil these conditions, Kohlrausch at first employed currents generated by the revolution of a magnet, inside a coil of wire, about a transverse axis in the median plane of the coil; in later modifications of the method the alternate currents of an induction coil were used. This investigation formed the starting point of a long and laborious series of researches by Kohlrausch himself and his pupils into the conducting power of electrolytic solutions. The examination of a great number of soluble salts in aqueous solutions of different concentrations showed that, although with dilute solutions conductivity decreases with decrease of concentration, yet the ratio of conductivity to concentration in general increases, at first nearly uniformly, but afterwards more slowly, so as to approach, in the case of each salt, a definite limit which may be called the ratio for an infinitely dilute solution. When the concentration of the solutions of different salts was expressed, not in terms of the unit mass of each salt, but in terms of its molecular mass, it was found that the ratio of concentration to conductivity was nearly the same for many allied families of salts, and that the agreement usually became closer with greater dilution. From the general results of the measurements of the conductivities of dilute solutions, Kohlrausch deduced the important conclusion that each of the ions into which an electrolytic salt may be supposed to be broken up when dissolved, moves with its own proper velocity under the influence of electromotive force, and he concluded that the conductivity of a dilute solution of a salt is simply the sum of the velocities of the anion and kation respectively under an electromotive force of one volt per centimetre. Combining this result with the ratio of the velocities, which can be deduced from Hittorf's measurements of the migration of ions, Kohlrausch deduced actual values for the mobilities of a large number of ions, and these agreed very satisfactorily with the measured conductivities of solutions of salts wherein these ions occur. This work formed the foundation of the modern electrolytic theory of solution.

Kohlrausch was one of the earliest among the teachers of physics to systematise a course of laboratory instruction for their students. His 'Leitfaden den praktischen Physik,' first published in 1870, was a most valuable help to other teachers who were in those days striving to get a general recognition by educational authorities of the fact that practical instruction in the laboratory was as essential, in the case of students of physics, as similar instruction had long been acknowledged to be in the case of students of chemistry. This book was translated into English by T. H. Waller and H. R. Procter soon after its first appearance, and a second English edition was published in 1883. In Germany it has gone through a great number of editions, the author continuing his careful revision and improvement to the last.

G. C. F.

SIR CHARLES TODD, K.C.M.G., 1826—1910.

Charles Todd died on January 29, 1910, leaving behind him more than sixty years of strenuous service to England and to South Australia. The great achievement by which he will always be remembered was his construction of the overland telegraph line from Adelaide to Port Darwin, which has been for the last forty years a main link in the chain of communication between the Australian Colonies and the old world. This was, however, but one of the many deeds he accomplished in the public service. So high a value was placed on the work which he had done for Australia that in the later years of his long life he was one of the best known and most revered men in the Commonwealth.

Todd was born at Islington on July 7, 1826, and was educated at Greenwich. In December, 1841, he entered the Greenwich Observatory as astronomical computer under Airy. In after years he often spoke of the hard work and severe discipline which Airy enforced. Yet he had a sincere liking and admiration for his stern chief, and his stories were always full of generous humour. From 1848 to 1854 he was assistant astronomer at Cambridge under Challis. In May of the latter year Airy asked him to go back to Greenwich to take charge of the new galvanic department: his work included the transmission of time signals to various parts of the country, and the dropping of time balls. In February, 1855, he was returning from a visit to Deal, where he had been readjusting the time ball apparatus at the Royal Dockyard, when he received at Tonbridge a letter from Airy, offering him, on behalf of the Colonial Office, the post of Superintendent of Telegraphs and Government Astronomer of South Australia.

With the consent of Alice Bell, of Cambridge, he accepted the offer. They were married, and left England in July, 1855, on board the "Irene," a sailing-ship of a few hundred tons. They landed at Adelaide on November 5, on which day, curiously enough, was completed the first telegraph line constructed in the province, a cheap private wire from Adelaide to Port Adelaide. After a year of small things, Todd brought forward his first great project, the connection of Adelaide and Melbourne by telegraph. Sailing to the latter city, he found himself the guest of the Victorian Commissioner of Trades and Customs, H. C. E. Childers, who was afterwards Chancellor of the British Exchequer. He succeeded in persuading Childers and his colleagues to take up the scheme, and rode back the 600 miles to Adelaide, mostly through the bush, alone, planning the route for the line. The work was finished in 1858, and a second and longer line from Adelaide to Sydney was completed shortly afterwards. He took advantage of the opportunities thus afforded him to make an accurate comparison of the longitudes of Adelaide, Melbourne, and Sydney, and also to find the position of the 141st meridian, which was the boundary between Victoria and South Australia. It turned out that the boundary had hitherto been placed two and a quarter miles too far west, so that Victoria was in unlawful possession of a strip of land belonging to the sister State.

His success in linking Adelaide to Melbourne and Sydney encouraged him to bring forward in 1859 the far greater scheme of the trans-continental line. It has to be remembered that most of the country to be crossed was practically unexplored; it was known only that great tracts of it were waterless desert. Northern Australia had been traversed by Gregory's expedition in 1856 from the Victoria River to the Dawson River and Moreton Bay. Todd read eagerly the history of the journey and the description of the country through which the expedition had passed, and he conceived the idea of pushing a line north from Adelaide right through the heart of the continent to emerge near the point where Gregory had entered. He could but guess at the nature of much of the interior, for Gregory had only crossed the northern portions; but the greatness of the scheme filled his mind, and he saw what its accomplishment would mean to the Australian Colonies. In that year (1859) he submitted his scheme to MacDonnell, the Governor of South Australia. In 1861–2, McDouall Stuart and his party accomplished their famous journey from south to north of the continent, actually going over most of the country through which the proposed line should run. In 1863, Todd reported that: "Whatever differences of opinion may have previously existed as to the practicability of making the vicinity of Van Diemen's Gulf the terminus of the land line, the return of Messrs. McKinlay and Stuart can leave no room for further doubt. The erection of an overland telegraph line to the north coast should be regarded as a national work, in the carrying out of which all the Colonies should unite." Men were afraid, however, of the magnitude of the task; but, in 1870, Todd's untiring advocacy at last persuaded the South Australian Government, under Strangways, to take up the scheme. The Eastern Extension Telegraph Company had offered to lay a cable from Singapore *viâ* Java to Port Darwin; the several Australian Colonies were asked to help South Australia to meet the offer, but declined, so the small State had the honour of taking up the work alone. The distance to be covered was rather more than 2,000 miles; yet the greatness of the proposal did not lie so much in its mere magnitude as in the absolute novelties of the difficulties to be overcome. It was an immense stride from the venturesome march of a handful of explorers across the continent, to the almost contemptuous conquest of the desert by construction parties doing their work steadily day by day. The most careful plans were necessary; quantities had to be decided on a large and unusual scale, natural difficulties had to be guessed at and allowed for, and all the time the critics had to be met. Transport was, of course, one of the most serious considerations of all; as much as £130 a ton was sometimes paid. Fortunately, two of the most terrifying of possible anticipations were not realised; there was no quantity of sickness, nor was there any serious trouble from the natives. Indeed, the relations with the aborigines were rather humorous, even when irritating. Who was to foretell that the porcelain insulator could be chipped into an excellent spearhead, which could be bound to the shaft in a workmanlike manner by the aid of a little of the wire left hanging on poles by the white man? However, this fashion soon went out, hurried a little perhaps by the judicious use of the magneto machine; and the natives learnt to respect the construction which they did not understand, and even made lines of their own of sticks and string.

The contractor for the central portion of the line broke down and abandoned his undertaking. When Todd and his political chief discussed the grave situation, there was no possible decision but one; Todd must go and do the work himself. Before his vigorous attack the difficulties melted away, though not in a moment. He took the abandoned 1000-mile stretch in flank, brought the steamer "Omeo" with all his material to the mouth of the Roper River in the Gulf of Carpentaria, signed a contract with the captain as they lay outside the bar of the almost unknown river indemnifying him from the consequences of obeying orders which might lead to the loss of the ship, and triumphantly carried her eighty miles up the stream. He re-organised the transport, infused cheerfulness and enthusiasm into his men, rode every mile of the long track, surveying, planning, encouraging, until at last the work was done. Surely there have been few more striking incidents of modern enterprise than that which occurred on a cold night of August, 1872, when Todd sat down on the ground near Central Mount Stuart, with the line to the south in one hand and that to the north in the other, and joined the new countries to the old. With a little pocket instrument he spoke either way. The news spread in Adelaide and his friends came crowding to send delighted messages of congratulation. The happy man sat for hours receiving and sending, until, overcome with weariness and sleep, he begged to be allowed to say "good-night."

For thirty-eight years the trans-continental line has been part of the main channel of communication between England and Australia. A great commerce has used it freely and thriven upon it, and its effects on Australian life and progress are not to be calculated.

The last of his great telegraphic undertakings was accomplished when he carried a line from Adelaide along the shores of the Great Bight to Eucla, on the West Australian border. Thus all the Australian States were put in touch with each other. His own State he covered with a network of means of communication, and he lived to see the telegraphic revenue mount to nearly £100,000 a year, though in the first months after his landing in South Australia it had been so small sometimes as fifteenpence in the day. In 1870 he was made Postmaster-General, and his new department also prospered. In 1906 its gross revenue was £200,000.

During this life so full of other work he did not forget his duties as Government Astronomer. The excellent little observatory in Adelaide is a testimony to his energy and his real love for astronomical science. He organised the meteorological observations of the State, and the climatic conditions of South Australia have been thoroughly well recorded and classified. With the aid of his own widely scattered offices, and his connections with the telegraphic systems of the other States, he was able to publish, and was indeed a pioneer in the publication of, weather maps. The excitement of the weather forecast was a daily incident of his life. He observed the transit of Venus in 1874, and again in 1882. On the latter occasion he took his instruments to Wentworth, on the New South Wales border. This place was in a position of strategical importance in regard to the transit, and his observations had therefore a peculiar value. He took a prominent part in the government of the public institutions of learning in the State; appeals for expert advice came to him from far beyond the limits of his own country. He spent sixty-four years in the service of the empire, fifty of them in South Australia, and the South Australian Parliament refused to pass the Bill for the compulsory retirement of septuagenarians so long as he would remain their officer.

On the completion of the overland line he received the distinction of a C.M.G., and in 1893 was advanced to a knighthood in the same order. Cambridge conferred on him the honorary degree of Master of Arts in 1886, and he became a Fellow of the Royal Society in 1889.

He had no commanding personality; at a first glance it might have been difficult to discover the source of his power. He was clearly a bright and happy man—kind, generous, full of vitality, with a perfectly boyish love of fun. Those who worked with him soon recognised his sense of proportion, his strong grasp of essentials, his acute understanding, and untiring energy. Yet, to those who knew him best, it seemed that the main secret of his success lay deeper still. It was his conviction that all those who served under him or with him were as enthusiastic as he himself for the success of the work to which they were pledged. He had no idea of using his position for his own advancement, and his natural impulse was to believe that the purpose of every man in his employ was as single as his own. As might be expected, he rarely failed to find what he thought to see. The whole of his great department was infected with his sense of duty and loyalty, his kindly courtesy and good humour. His remarkable capacity for organisation would in any case have created an efficient machine, but the simple goodness of his nature made his men happy in their work.

One of the most remarkable features of the public life of Australia has been the efficiency of the long series of men who have served her as heads of departments, judges, engineers, educators, geologists, astronomers, and so forth, and a very interesting account might be given of the causes which brought them forward and of the services which they rendered. Of these splendid public servants Todd was one of the best.

W. H. B.

GREVILLE WILLIAMS, 1829—1910.

Charles Hanson Greville Williams, son of S. Hanson Williams, a solicitor, was born at Cheltenham, September 22nd, 1829. His death took place in his little cottage at Smallfields, Horley, on June 15, 1910.

His early attempts to study practical chemistry did not receive the paternal approbation; indeed, on one occasion, when the boy's pocket-money, saved up for many weeks, had been expended in the purchase of a "chemical chest," the father, with a sweep of his cane, consigned the newly-acquired treasures to destruction.

It was at the house of Dr. J. H. Gladstone, in Tavistock Square, that the writer of this notice first met Greville Williams: this was in the early fifties —probably in 1852 or 1853—when the young man was at work as a consulting and analytical chemist in Oxford Court, Cannon Street. He soon migrated to Glasgow, on being appointed first assistant to Prof. Thos. Anderson, of Glasgow University, for whom, during three years, he carried out much research work; afterwards he conducted a tutorial class under Dr. Lyon (since Lord) Playfair, at Edinburgh. During 1857 and 1858 he was lecturer on chemistry in the Normal College, Swansea. In 1858 he returned to Glasgow as chemist to the works of George Miller and Co., manufacturing chemists. Greville Williams moved to Greenford Green in 1863, remaining with Messrs. Perkin until 1868, when he entered into partnership with M. Edouard Thomas and Mr. John Dower, at the Star Chemical Works, Brentford, the firm being makers of coal-tar colours and subsisting until 1877. Mr. (now Professor) R. Meldola, F.R.S., and, after his retirement in 1872, Dr. Otto N. Witt, were in the service of this firm as chemists. It was under the auspices of Dr. Witt that some of the first azo-compounds were manufactured in this country by the firm of Williams, Thomas, and Dower. On the closing of the works Greville Williams gave up his connection with manufacturing chemistry and became photometric supervisor to the Gas Light and Coke Company, with whom he remained until 1901. He then retired into the country, living the life almost of a recluse, and seldom seeing his old friends and acquaintances.

At this time he had become much interested in the language of ancient Egypt, and was acquiring considerable facility in the reading and interpretation of hieroglyphic inscriptions. In this connection may be quoted a passage from a letter dated December 12, 1904, where, writing about the Sarcophagus of Seti I. in the Soane Museum, he says: "It is a real misfortune that the sarcophagus is placed where it cannot be photographed, because the old engravings of Egyptian monuments frequently exhibit mistakes in the hieroglyphic texts, but even the scribes and sculptors of the ancient dynasties were by no means impeccable in that respect, as I found when transliterating and translating the stele of Menthusa." Until rheumatism disabled him, he was an expert draughtsman and calligraphist, a fair game-shot, and an enthusiastic angler.

Although in reality a delightful companion endowed with unusual conversational powers and a keen appreciation of literary and artistic culture, Greville Williams possessed a sensitive and modest temperament which tended, especially in his later years, to isolate him from his fellows. He was, perhaps, rather more nervous about his state of health than he need have been, and in consequence, withdrew almost entirely from scientific and social intercourse. It may likewise be considered that his straitened circumstances tended in the same direction, particularly as they debarred him from continuing his researches in pure chemistry. Whenever the conditions of his daily life allowed him leisure and opportunity for original enquiry, he was an enthusiastic worker, possessed of the true chemical instinct and a general scientific aptitude, as well as a large measure of manipulative dexterity and invention. It ought to be added that Greville Williams was a most interesting correspondent, and, having a happy knack of versifying, often passed from prose into poetry in letters addressed to his more intimate friends. Two epistles of this order are at the present moment before the writer. One of these, dated March 1, 1861, deals in a playful way with the deceitfulness of unsupported spectral observations, the later epistle, written a quarter of a century afterwards (August 20, 1885), includes some humorous verses on a literary topic.

Most of Greville Williams's research work was concerned with certain groups of hydrocarbons and of volatile bases produced in the destructive distillation of organic substances, including combustible shales and coals. He made, however, a few incursions into mineral chemistry, especially in reference to peculiarities in the composition of the variety of beryl known as emerald.

Two discoveries of unusual interest were made by Greville Williams. One of these was the isolation of the most remarkable of the pentinenes, namely, isoprene ('Phil. Trans.,' vol. 150, pp. 241–255, 1860). Of this hydrocarbon he determined the physical constants with accuracy; it has risen in importance since its polymerisation* into caoutchouc has been achieved, and since it has been obtained from terpene. In this connection it is of interest to remember that Greville Williams ascertained that caoutchouc and terpene absorbed the same proportion of bromine. The other chief result of Williams's work was obtained in the study of quinoline bases, when he discovered cyanine or quinoline-blue ('Trans. R.S. Edin.,' vol. 31, p. 377, 1856). This body, $C_{29}H_{35}N_2I$, was the first of the quinoline dye-stuffs to be prepared. Some of these beautifully crystallised bodies have met with considerable application in photography as special sensitizers, but none of them is even tolerably fast to light.

Among the basic constituents present in certain kinds of tars from shales and coals, and in the products derived from the destructive distillation of cinchonine in the presence of potash, Greville Williams recognised and isolated several important bases. Pyridine was one of these; so also was a lutidine, perhaps a mixture of two or more of the nine possible lutidines, as well as a collidine, or a mixture of two or more of the twenty-two possible collidines; all these were found in coal tar, in Dorset shale tar, and in the distillate from cinchonine. Quinoline or leucoline, discovered by Runge, was first thoroughly investigated by Williams ('J. Chem. Soc.,' (2) 1, p. 375). Some of the members of this series of bases are of great practical importance in the synthesis of certain medicinal preparations; γ-methyl-quinoline was first obtained by Williams from cinchonine, and named lepidine (B.P., 257°): it is thought to be identical with his iridoline from coal tar. He also described, under the name of cryptidine (B.P., 274°), one of the dimethyl-quinolines—perhaps the 2·3 or the 3·4 dimethyl-quinoline of Behrend.

Much useful work was accomplished by Greville Williams in connection with the platinum compounds of the volatile bases which he examined. Some of his results were given in memoirs already named or were discussed in notes appearing in the 'Phil. Mag.' for September, 1854, and in the 'Chem. Gaz.' for August 16, and September 1 and 15, 1858. His determinations of vapour density were distinguished for the care and precision with which they were performed: these and other constants of many organic compounds were first accurately determined by him.

To about a score of memoirs and notes on organic bases which are credited to Greville Williams in the Society's Catalogue of Scientific Papers, there must be added about fifteen devoted to hydrocarbons. And during the period 1882–1885, half a dozen enquiries of a technical character, connected with coal-gas and its manufacture, were carried out and reported upon, mainly in the 'Journal of Gas Lighting.'

Greville Williams made, as before stated, a few incursions into the domain of mineral chemistry. Chief among these were his researches on beryls and emeralds which appeared in the 'Proc. Roy. Soc.' during 1873 and 1877,

* See the memoir just cited for an intimation as to such a change.

vol. 21, pp. 409—421, and vol. 26, pp. 165—175. The earlier of these papers was devoted mainly to problems connected with the colour of the emerald but included an account of experiments on the fusion of beryl, quartz, and sapphire by means of the oxy-hydrogen blowpipe. The precautions necessary to secure clear beads of these substances were defined, while the lowering of density by their passage into the vitreous state was accurately recorded. In the second memoir the chief method in use for effecting a separation between glucina (beryllia) and alumina was critically examined and greatly improved.

Two class-books were written by Greville Williams. The more important of these was published in 1857 under the title "A Handbook of Chemical Manipulation." It contains 407 illustrations with an appendix of twenty useful tables: a supplement dealing with more recently devised apparatus and methods was brought out in 1879. The other class-book was a "Manual of Chemical Analysis for Schools," which appeared in 1858. He also wrote numerous articles for Ure's "Dictionary of Arts, Manufactures, and Mines," for Watts's "Dictionary of Chemistry," and for King's "Treatise on Coal Gas." His contributions were clear and exact, while in his accounts of materials and operations his personal experience was largely drawn upon.

In June, 1862, Greville Williams was elected to the Fellowship of the Society; he outlived the rest of the distinguished "fifteen" of that year. It was in 1862 also that he joined the Chemical Society. On November 25, 1852, he married Henrietta Bosher, who died on February 16, 1904. One son and three daughters survive.

The writer of this memorial notice has lost a friend of nearly sixty years standing—a friend of rare quality and of high Christian character.

A. H. C.