OBITUARY NOTICES.

THOMAS VIPOND BARKER.

1881—1931.

THOMAS VIPOND BARKER was born at Darwen, Lancs., on March 7th, 1881, and was educated at Kirkham Grammar School. His early interest was in chemistry, at which he worked ardently both at home and at school. He took London University Matriculation and Intermediate B.Sc., and in Michaelmas Term, 1900, entered at Exeter College, Oxford, as a Commoner.

He became so interested in mineralogy during his first year that he not only worked in the University Mineralogical Laboratory but obtained leave of absence for a year from his College in order to study under Professor von Groth at Munich. There he attended lectures in mineralogy and chemistry, and a course of practical physics under Professor Roentgen, and began some research work in crystallography. Returning to Oxford in 1903, he took the final Honour School in chemistry in 1904, Class II, with distinction in mineralogy and crystallography. His College then gave him a Research Exhibition which enabled him to devote a year to research work in the Mineral Department of the University under my direction.

During this period he began his investigation of the regular growth of crystals of one substance on those of another; his first paper on this subject was published in the Journal of the Chemical Society (1906, **89**, 1120). Meanwhile, in December, 1905, he was elected by Magdalen College to a Senior Demyship tenable for four years, and in 1906 obtained the Degree of Bachelor of Science by a dissertation on the regular growth of crystals on each other. He was also awarded the "Daniel Pigeon Prize for Research" by the Geological Society.

Being anxious to gain wider experience by continuing his researches abroad, he decided at my suggestion to go to Professor Fedorov, who was then Director of the Imperial Russian School of Mines and a most original and inspiring crystallographer. For two and a half years he devoted his spare time to the study of Russian, went to Petrograd in January, 1908, and spent more than a year in Fedorov's laboratory, assisting him with material for his great work on Crystallo-chemical Analysis referred to below.

In 1909, when his Magdalen Demyship expired, he returned to Oxford, and was appointed Demonstrator in the Mineral Department. In 1913 he was elected to a Research Fellowship at Brasenose College and in 1914 was appointed University Lecturer in Chemical Crystallography.

In 1920 his Fellowship became an official one and subsequently the title of his post was Reader in Chemical Crystallography; in 1925 he took his D.Sc. degree.

In 1925 Barker had the opportunity of showing his capacity for administrative work, when he became Secretary to the Delegates of the University Museum, a post which he held for three years.

A further opportunity was given by the meeting of the British Association in Oxford in 1926, when, as Chairman of the Accommodation Committee, he was to a large extent responsible for the local arrangements, and instrumental in raising the necessary funds.

When the post of Secretary to the Curators of the University Chest became vacant in 1928, Barker was felt on every ground to be the right man for this important financial and administrative office, which he held for the remaining three years of his life, and which involved the resignation of his teaching appointment.

At the time of his death he was also a Delegate of the University Museum and a member of the Council of Somerville College.

Barker established his position as a scientific investigator by the important research on the parallel growth of the crystals of one substance on those of another. A number of isolated instances had been recorded by previous observers, among which the parallel growths of sodium nitrate on calcite, of potassium iodide on mica, and of several isomorphous substances on each other are the most familiar, in addition to many examples among minerals. Barker made a complete study of the other members of the calcite group in relation to sodium nitrate; followed this up by a similar study of the perchlorates and permanganates and their relation to the barytes group; examined in the same way the mutual relations of the chlorides, bromides, iodides, and cyanides of sodium, potassium, rubidium, cæsium, and ammonium; and extended his investigation to the alkaline sulphate–chromate group, with the object of ascertaining why some pairs of substances crystallise in parallel positions on each other while others do not.

These researches were published in various papers contributed to the Journal of the Chemical Society, the Mineralogical Magazine, and Groth's "Zeitschrift für Krystallographie," and are summed up in a memoir in Vol. 55 of the Zeitschrift (pp. 1—62; 1908).

They led him to the quite definite conclusion that the determining factor is not merely isomorphism but the equality or close similarity of molecular volume. In other words, it is not enough that two substances should possess a similar structure; the structures must also be equally, or nearly equally, spaced. This is most conveniently expressed in terms of their topic axes, which must therefore be nearly identical to produce such parallel growths.

This investigation was supported by a grant from the Chemical Society.

Barker published a number of other papers containing crystallographic investigations on various organic compounds. He also contributed the sections on mineralogical chemistry and mineralogy in the Annual Reports of the Chemical Society in 1914 to 1921. He wrote the article on crystallography in the 5th and 6th editions of Roscoe and Schorlemmer's "Treatise on Chemistry," and the article on crystallography in "Chemistry in the 20th Century," published in 1924.

He interested himself much in all modern methods of crystallographic research, and never relinquished the work which he had begun under Fedorov with the object of establishing a systematic method of classifying all known crystallised substances in such a manner that they could be identified from a single measurable crystal without recourse to analysis. The work of Fedorov and his collaborators on this subject resulted in the enormous set of tables, published in Petrograd in 1920 by the Russian Academy of Sciences, under the title "Das Krystallreich, Tabellen zur Krystallochemischen Analyse, E. von Fedorov, unter Mitwirkung von D. Artemiev, Th. Barker, B. Orelkin und W. Sokolov"; with an accompanying Atlas of Crystallographic Projections.

For years it was Barker's intention to write an account of the principles on which Fedorov's classification was based, and the method by which any crystal can find its proper place in these tables. It depends upon giving to each an arbitrary but fully defined orientation, and then classifying them by one characteristic angle in each case, so that any substance can be identified at once by the measurement of its characteristic angle. The methods were not familiar to anyone in this country besides Barker; Fedorov himself never published an explanation of his tables before his death, and they remain in consequence practically useless, or at least incapable of use except by those who worked with him.

In the year 1917 Barker had illustrated the use of the methods by his identification of a substance found in the human body and sent to him for identification by Dr. P. Govaerts. Measurement of a single crystal enabled him to identify it as salol.

A large amount of material for such a work had been gathered together by Barker during a number of years; it was his intention to publish a treatise on the subject and to accompany it by tables of all substances which had been measured and described since the publication of Groth's "Chemische Krystallographie," and were therefore not included in that great book of reference; and further, with the co-operation of workers in different countries, to complete the necessary tables, which should ultimately include all known crystallised substances. He had come to the conclusion that the principles on which Fedorov's classification was based were unsatisfactory, since they made certain assumptions concerning structure which are not in conformity with modern views, and his own tables were to be of a somewhat different character.

In the last year of his life, feeling that his time was becoming more and more occupied by administrative work and that he could only devote his scanty leisure to the purpose, he brought out a small book entitled "Systematic Crystallography, an Essay on Crystal Description, Classification, and Identification," which bears signs of having been written in haste. This book contains a brief statement of the principles and some examples of the classification, showing how any substance, whatever its composition, can be quickly identified by a single angle, if care has been taken to set it up with the prescribed orientation.

Barker took the greatest interest in teaching, was a very accomplished and lucid lecturer, always in close sympathy with his students. In addition to his ordinary university work he had for many years in succession held classes on crystallography for science teachers who visited Oxford for annual Summer Courses. In 1920 and 1921 he published, in connexion with these courses, two pamphlets concerning the study of crystals in schools, and shortly before his death he issued a little book entitled "The Study of Crystals," which summed up the contents of these pamphlets and constitutes an excellent handbook for teachers who wish to introduce the subject into their school curriculum.

In 1922 Barker had published a small book of considerable originality on graphical and tabular methods in crystallography.

The foregoing brief account of his career may suffice to show that a life of great scientific promise with a fine record of achievement was cut short by his premature death. From undergraduate days he had been powerfully attracted by the study to which all his energy was subsequently devoted; early and late his thoughts were concentrated upon crystals, and although his time had recently become fully occupied with administrative work, it was clearly his intention to continue his cherished project of a comprehensive system of determinative tables for all known crystals on the lines of his "Systematic Crystallography."

Though of a somewhat retiring disposition as a young man, Barker was subsequently brought into contact with many people by his official position, made many close friends, and attracted all who met him by his cheery and lovable character and steadfast sympathy. He possessed a fund of humour which generally expressed itself in quaint turns of phrase both in his conversation and in his writings.

In 1911 he married May Marion Elizabeth Graham, who survives him; their married life was one of unbroken happiness.

HENRY A. MIERS.

ETHELBERT WILLIAM BLAIR.

1895—1931.

ETHELBERT WILLIAM BLAIR was killed in an explosion of nitroglycerine which occurred at the Royal Naval Cordite Factory, Holton Heath, Dorset, on June 23rd, in his 37th year.

He was educated at the Tottenham County School, at East London College, and at the Imperial College of Science and Technology. He gained the Neil Arnott Scholarship, graduated B.Sc. with honours in chemistry in 1913, and was awarded the diploma of the Imperial College in 1915. In the same year he joined the staff of the Royal Naval Cordite Factory and was entrusted with experimental research, and in 1921 was appointed chemist in charge of the chemical laboratory. He contributed a number of papers to the Journal of the Chemical Society, the Society of Chemical Industry, and to the *Analyst*. He was elected an Associate of the Institute of Chemistry in 1918, and a Fellow in 1924. He was also elected a Fellow of the Chemical Society on February 19th, 1914.

W. T. T.

FRANK WIGGLESWORTH CLARKE.

1847—1931.

PROFESSOR F. W. CLARKE, a well-known American chemist, died at Washington, D.C., on May 23rd, 1931, at the ripe age of 84. For forty-two years (1883—1925) he was Chief Chemist of the United States Geological Survey, and during the same period also Honorary Curator of Minerals in the United States National Museum. By his genial personality and enthusiasm he was well known to many workers in England, being an Honorary Member of the Chemical, Geological, and Mineralogical Societies of London and Honorary Doctor of the Victoria and Aberdeen Universities.

He was born at Boston in Massachusetts on March 19th, 1847, and graduated at Harvard University in 1867. After acting as Instructor in Chemistry at Cornell and Harvard Universities, he became Professor of Chemistry and Physics in Howard University (Washington, D.C.) and the University of Cincinnati (Ohio), holding the latter post during the period 1874—1883. While still engaged in teaching, he commenced the well-known series of numerical compilations under the title "The Constants of Nature," including: I, Specific gravities, boiling and melting points (1873); II, Specific heats (1876); III, Expansion by heat (1876); IV, Atomic weights (1880); V, Recalculation of atomic weights (1882). Some of these tables passed through several editions, and they led to his life-long work on American and International Committees on atomic weights, small committees of which he was usually the chairman. During his long connexion with the United States Geological Survey he was responsible for numerous chemical analyses of minerals and rocks, and the data obtained were tabulated in a series of Bulletins of the Survey. In other Bulletins he discussed in detail the chemical constitution of mineral silicates, the arguments being based on a large amount of experimental work made with the view of obtaining substitution products. His best known work, also published as a Bulletin of the Survey, is his "Data of Geochemistry," which passed through five editions (1908—1924), and, with Dr. H. S. Washington, "The Composition of the Earth's Crust" (1924). He was also the author of elementary text-books on chemistry, and in later years he published several papers on the inorganic constituents of marine invertebrates. A new uranium mineral has recently been named clarkeite in his honour. He was President of the American Chemical Society in 1901.

L. J. S.

HAROLD BAILY DIXON.

1852—1930.

Harold Baily Dixon, whose work upon gaseous explosions opened a new era in combustion research, was born in London on August 11th, 1852, the second son of William Hepworth Dixon (1821—1879), traveller and historical writer, who for some years was editor of the *Athenæum*. Although the family came of an old Lancashire Puritan stock, the Dixons of Heaton Royds, the grandfather of the chemist was Abner Dixon of Holmfirth and Kirkburton in the West Riding of Yorkshire, and his grandmother was Mary Cryer of those parts.

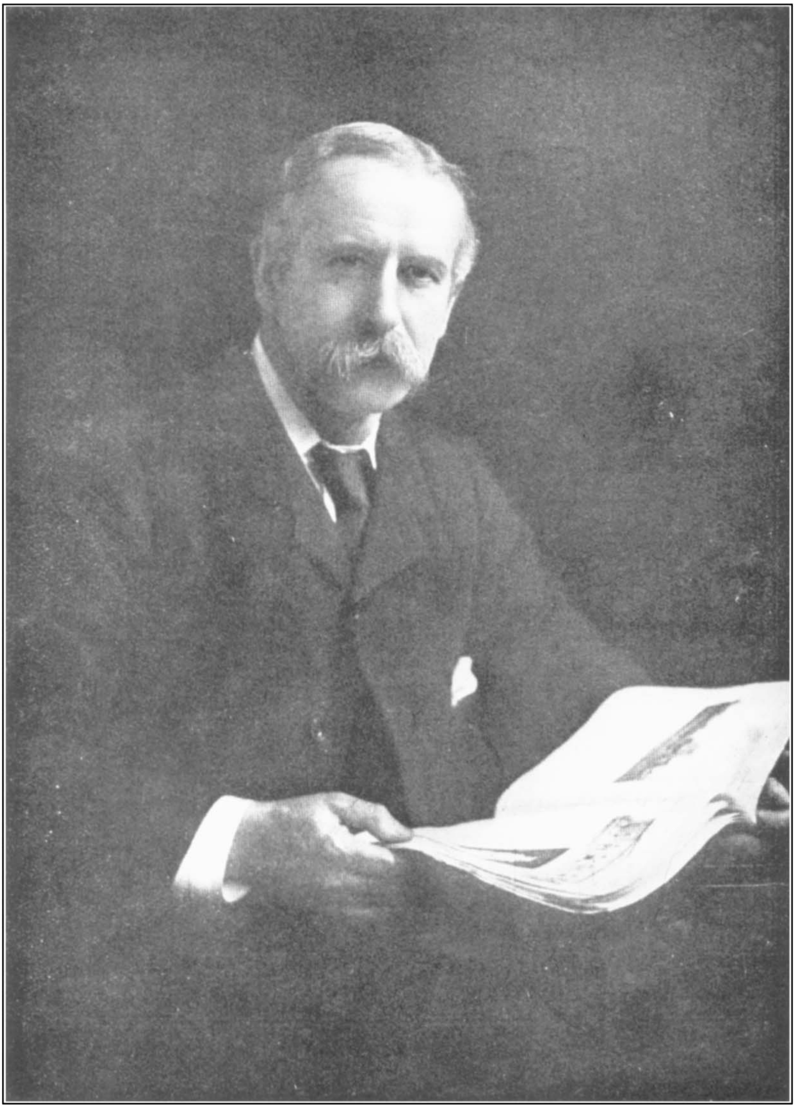
His father, William Hepworth Dixon, who was born in 1821 at

Great Ancoats in Manchester, began life as a clerk in that city; but early resolving to adopt literature as a career, he became associated with a group of literary men, including Harrison Ainsworth, who were working in Manchester in early Victorian days. In 1846, at the instance of his friend Douglas Jerrold, he migrated to London; and, having early married a lively good-looking Irish girl, Marion MacMahon, they had eight children, of whom Harold Baily (second son) and Ella Hepworth (youngest daughter) achieved distinction in science and literature respectively.

William Hepworth Dixon travelled extensively and wrote many popular historical books in a lively and attractive style. His house in Regent's Park was resorted to by a brilliant group of friends, among whom were Richard Burton, Bulwer Lytton, Frederick Leighton, John E. Millais, Thomas Firth, T. H. Huxley, Henry Irving, J. L. Toole, as well as J. M. Levy, founder and editor of the *Daily Telegraph*, and a certain tall good-looking sapper called Kitchener. It has been said that, "although occasionally deficient in tact, Hepworth Dixon was faultless in temper and seldom put out by any disappointment or misfortune." His sympathies were with the people, and he took a leading part in establishing the Shaftesbury Park and other centres of improved dwellings for the labouring classes. As a member of the first London School Board (1870—1873) he carried a resolution, in the teeth of strong opposition, establishing physical drill in all rate-paid schools throughout the metropolis; and in 1874 he persuaded the then Prime Minister (Disraeli) to order the opening of the Tower of London to the public free of charge. Besides good looks and physical build, Harold inherited from his father the exceedingly equable temper, liberal views, and strong current of sympathy for working people and their material and intellectual welfare, which characterised his future life work at Manchester University among the men of Lancashire and Yorkshire.

His mother was a woman of innate good taste and manners, with advanced views upon the subject of women's suffrage; she went by herself to all Ibsen's plays, when they were first produced in London, and called in a lady doctor when her youngest son was born. Except, perhaps, for a certain liveliness on occasions of unusual excitement, when he would let himself go, it would be difficult to trace what influence her Irish blood may have imparted to her son Harold, who outwardly showed little sign of it, and was singularly reticent about his parents and early home-life.

In 1867 Harold was elected foundation scholar at Westminster School, from whence in 1870 he obtained a classical junior studentship at Christ Church, Oxford. As an undergraduate he was one



Harold B. Dixon

[*To face p.* 3350.]

of the most popular men of his time and threw himself into the social and athletic side of university life. He rowed in the College eight, played cricket, and obtained his blue in association football, taking part in the last game in which a University team won the English cup. He was also extremely fond of dancing. These activities so much interfered with his classical studies that he scarcely fulfilled the expectations of his tutors and there was a danger of his University career being brought to an untimely end. Fortunately, however, in 1873, Dr. A. Vernon Harcourt induced the College authorities to transfer the young classical scholar to his care, and was thus responsible for saving for chemical science one who was destined to be numbered among its most original and lucid exponents.

Two years later Dixon graduated first-class in the Natural Science School, and was elected to a fellowship at Trinity. He then started research work with Harcourt, who, some eight years previously in conjunction with Essen, had published his classical work on the rate of chemical change between solutions of hydrogen peroxide and hydriodic acid, which may be said to have founded modern chemical dynamics. Until 1879 Dixon and Harcourt worked side by side in the crypt of one of the monastic buildings on the site of which Christ Church was built. It was the room in which the first anatomical studies were carried on, chiefly upon the bodies of malefactors who had been executed within the precincts of the Castle near by. Also it was in this room that, in the seventeenth century, the fortunate (or unfortunate) Mary Baker was revived by the surgeons after she had been hanged for an hour. Despite such gruesome associations, however, it made an admirable chemical research laboratory, being very quiet, of even temperature, and comparatively free from dust.

In 1879, Balliol and Trinity College combined in a joint scheme for the teaching of science whereby Trinity established the Millard Lectureship, to which Dixon was forthwith appointed, and Balliol provided a laboratory and lecture room. A doorway, dubbed the "scientific frontier," was opened between the two Colleges so that Trinity men might have easy access to the new rooms. Dixon then transferred his research work to a cellar in the garden quadrangle which had been used by Benjamin Brodie for his investigations upon ozone. It was damp and dark, and being devoid of any draught chamber, fumes used to rise up the staircase to the annoyance of the undergraduates having rooms above, who on one occasion were provoked to reprisals. One day, also, Dixon was so badly gassed by an accidental escape of carbonic oxide that, to the alarm of his assistant, he was in a state of complete aphasia for the next four hours. And on a third occasion, it was only his presence of mind in turning off the tap of a gasholder containing 30 cubic feet of an explosive mixture that prevented its being exploded by a flame originated by a premature spark in an apparatus which was being filled with it at the time. In 1886 he was elected to a fellowship at Balliol, and continued working there until he removed to Manchester in 1887, being assisted for some time (1883—1885) by H. B. Baker.

It was at the instigation of Vernon Harcourt that Dixon commenced studying gaseous explosions in 1876; although, curiously enough, two years previously (October 2nd, 1874) his father's house in Regent's Park, London, had been completely wrecked by concussion waves from an explosion of gunpowder on the Regent's Canal near by.

During the sixty years which had elapsed since Humphry Davy's pioneering work on the subject, only R. W. Bunsen amongst chemists had much explored it; and for twenty years his results had been accepted without question as authoritative. More particularly the results of Bunsen's experiments (1853) on the explosion of mixtures of electrolytic gas with increasing amounts of carbonic oxide were held to be inconsistent with the principle of "mass action" enunciated by Berthollet in 1805, and led to the curious view that a continuous alteration in the composition of such a gaseous medium produces a discontinuous ("*per saltum*") alteration in the course and products of its explosion.

In the year 1877, during the course of a research primarily undertaken to test Bunsen's conclusion, Dixon made his epoch-making discovery that the prolonged drying over phosphoric anhydride of a mixture of carbonic oxide and oxygen in combining proportions renders it non-explosive when subjected to electric sparks of an intensity sufficient to ignite readily an undried medium. He first announced it in a paper to Section B of the British Association at Swansea on August 28th, 1880 ("B.A. Reports," 1880, p. 503), on which occasion he demonstrated it experimentally, adding that although the smallest addition of steam, hydrogen or ether vapour to the phosphoric anhydride-dried $2CO + O_2$ medium rendered it explosive, neither dry nitrogen nor dry carbonic acid nor dry cyanogen had any effect, from which "it appears probable that the oxidation of carbonic oxide is really caused by the alternate reduction and oxidation of water molecules, according to the equation :—

(i) $$CO + H_2O = CO_2 + H_2$$
(ii) $$2H_2 + O_2 = 2H_2O.$$"

Subsequently Dixon proved that the speed of flame in a $2CO + O_2$

explosion, whether during the initial phase of uniform slow movement or even after " detonation " had been set up, increases with the moisture content of the medium, up to " saturation " at about 35° C. when about 5·6 per cent. of it is present, a result which has since been confirmed by other investigators.

This discovery aroused world-wide interest and opened up a new field of chemical investigation which ever since has continued to attract workers from all quarters, and still yields abundant fruits. For, as Dixon was wont to say, " it loosed a hare which, though since pursued by the hounds in full cry, is still uncaptured."

For many years much controversy raged round various chemical theories (including the one originally favoured by Dixon) which from time to time were put forward to explain the comparative inertness of dry carbonic oxide–oxygen media, and many important experiments were made in attempts to discriminate between them. M. Traube and Lothar Meyer in Germany, Beketoff and Mendeléeff in Russia, H. E. Armstrong, as well as Dixon and his pupils in this country, figured prominently in the discussions. Nowadays, while not rejecting the well-known chemical interactions both of steam and hydrogen peroxide with carbonic oxide as partial explanations (especially when massive proportions of such " promoters " are present) there is a growing consensus of opinion favouring a physical explanation of the phenomenon, which latterly Dixon himself more and more inclined to. Indeed, his last published words upon the subject (in reviewing some experiments upon the influence of a strong electric field upon the combustion of a rigidly dried $2CO + O_2$ medium) were that " it was evident that the resistance to combination offered by the dryness of the gases could be overcome by the electrostatic field . . . (so) that the problem presented by the burning of this gas has become one of the most interesting in physical chemistry."*

Dixon's early Oxford researches (1876—1881), besides proving, *contra* Bunsen, the validity of Berthollet's " law of mass action "—a conclusion which was simultaneously established by the independent work of Horstmann in Heidelberg—laid a firm and lasting foundation upon which much later work on equilibria in reversible gaseous interactions has been built.

Until the year 1880, on the strength of some measurements made by R. W. Bunsen in 1857, it was generally believed that gaseous explosions travel at rates not exceeding a few metres per second only; but on July 5 of that year a disastrous explosion in a 36-inch

* *Nature*, **129**, 582 (1929). Also a complete review of fifty years' work (1880—1930) on the subject is given in the Third Liversidge Lecture before the Chemical Society, by one of us (W. A. B.).

gas main in Percy and Charlotte Streets and Fitzroy Square near Tottenham Court Road, London, involving the loss of two lives and much damage to property in the neighbourhood, afforded conclusive evidence of much higher speeds. Vernon Harcourt, who had been called in to investigate the matter, suggested to Dixon the desirability of his undertaking a systematic investigation of the rates of propagation of flames in gaseous explosions generally, which he forthwith began. He had not got far with it, however, before Berthelot and Vieille announced (1880) their discovery of the high constant flame speeds finally attained on the development of " l'onde explosive " (" detonation ") in gaseous explosions. This revelation, together with the appearance of Mallard and Le Chatelier's classical *Recherches sur la combustion des mélanges gaseux explosifs,* in 1883, showed that the comparatively slow flame speeds observed and measured by Bunsen apply only to the mild and usually short initial phase of such explosions.

Working on parallel lines with these French savants during the next twenty years, Dixon so successfully developed the methods initiated by them that he soon became a leading authority upon the subject. In 1893 he gave the Bakerian Lecture on " The Rates of Explosion in Gases," and nine years later published in the *Philosophical Transactions* of the Royal Society a brilliant memoir embodying his photographic researches on " The Movements of Flame in the Explosion of Gases."

The method adopted by Dixon for measuring " rates of explosion " (" detonation ") in gaseous explosions followed closely in principle that originated by Berthelot and Vieille; but his determinations were more systematic and in some cases more accurate than theirs. They concluded that the velocity of the " explosion wave " is quite independent of the material and diameter of the tube employed, provided that a certain small limiting diameter is exceeded, as well as independent of the pressure; the last-named conclusion, however, Dixon subsequently found erroneous by showing the rate increasing slightly with pressure, at least up to two atmospheres. They termed it, for a given explosive mixture " *une propriété fondamentale ; car elle établit que la vitesse de propagation de l'onde explosive est réglé par les mêmes lois générales que la vitesse du son* "; and, assuming that it equals, or approximates closely to, the mean velocity of translation of the molecules at the moment of combination, supposing them to retain all the heat developed in the reaction, they proposed the formula

$$v = 29{\cdot}354 \sqrt{T/d},$$

where $T =$ the maximum temperature (abs.) reached in the explosion, and d = density of the products of combustion referred to air.

They further assumed (i) $T = Q/6{\cdot}8n$, where Q = the heat liberated by the chemical change involved in the propagation of the wave, and n = the number of "molecular volumes" taking part therein; also that (ii) the gases are heated at *constant pressure*, (iii) that the specific heat of a component is the sum of the specific heats of its constituents, and (iv) that "dissociation" scarcely affects the propagation of the wave, because of its extremely short duration and the high pressures developed therein. Although it so happened that the velocity (2810 metres per second) which they actually found for electrolytic gas ($2H_2 + O_2$) came very near the 2831 metres per second calculated on the foregoing assumptions, most of their other observed experimental values fell short of the so calculated values, and notably the observed 1089 as compared with the calculated 1941 metres per second in the case of a $2CO + O_2$ medium. This led them to regard their formula as "provisional" only, in the same sense that it gave a *limit* representing the *maximum* possible rate of propagation and subject to diminution in various ways, so that in many cases (as they said) "*la combustion se propageant alors de proche en proche suivant une loie beaucoup plus lente.*"

While adopting the "sound-wave" theory of Berthelot and Vieille in principle, Dixon subjected it in his Bakerian Lecture to a searching criticism in detail, more particularly in regard to certain of their assumptions, with which he disagreed. He sought to modify it so as to make it better fit the facts by supposing that (i) the explosion wave is carried forward by movements of molecules of density intermediate between that of the products of combustion and that of the unburnt gases, (ii) the gases are heated at constant volume (not constant pressure), (iii) the temperature of the gas propagating the wave is double that due to the chemical reaction alone, and (iv) that the velocity of a sound wave is only 0·7 of the mean velocity of the molecules in the medium through which it is passing.

Even when so modified, however, the "sound-wave" theory predicted in a number of cases (*e.g.*, most undiluted detonating mixtures) rates of explosion so much higher than those actually observed—*e.g.*, for undiluted electrolytic gas the "calculated" rate was 3416 as compared with the found value of 2830 metres per second—that eventually it had to be abandoned. Indeed, both its French authors and Dixon had quite erroneously assumed the heat capacities of gases to be independent of temperature, while Dixon over-estimated what he thought to be the limiting influence of "dissociation" in the wave. For in 1910, he confessed quite frankly, "I do not believe to-day in the truth of my working hypothesis of the explosion wave. It embodied a number of assumptions, some of which I have myself shown to be erroneous. The theory of the explosion wave is not to-day dependent on the hypothesis of Berthelot and myself." And at the same time he expressed his conversion to the newer views advanced independently by Hugoniot (1887—1888), D. L. Chapman (1899), Vieille (1899—1900), and E. Jouguet (1906), according to which "detonation" is essentially a "shock wave" propagated through a medium which is discontinuous in the vicinity of the wave front, in the sense that an abrupt change in pressure and density in the vicinity of the wave front is propagated and maintained from layer to layer by the adiabatic ignition of the explosive medium, a conception which has now superseded the former "sound-wave" theory.

The great and permanent value of Dixon's work in this connexion really lay both in his accurate and systematic measurements of "rates of explosion" ("detonation"), most of which were set forth in his Bakerian Lecture (*q.v.*), and in certain important conclusions which he deduced therefrom regarding the chemical reactions actually concerned in the propagation of the wave. Thus, for example :—

(i) His observed rates for the following cyanogen mixtures :—

$$\frac{C_2N_2 + O_2}{2728} \left\{ \begin{array}{cc} \dfrac{C_2N_2 + 2O_2}{2321} & \dfrac{C_2N_2 + 3O_2}{2110} \\ \dfrac{C_2N_2 + O_2 + N_2}{2398} & \dfrac{C_2N_2 + O_2 + 2N_2}{2166} \end{array} \right\} \text{metres per second}$$

showed that the gas burns in two well-defined stages, namely (*a*) primarily to carbonic oxide in the wave itself, and (*b*) afterwards to carbon dioxide behind it.

(ii) His observed rates (at 10° and 760 mm.) for the following hydrocarbons with varying proportions of oxygen showed that (*a*) there are distinct stages in the explosive combustion of a hydrocarbon, and (*b*) *in the wave itself*, the carbon burns primarily to carbonic oxide, which afterwards burns to carbon dioxide in the rear of the wave, the rate of explosion for a mixture containing sufficient oxygen for *complete* combustion being always much less than that for one containing only sufficient oxygen to burn the carbon to carbonic oxide; thus he found :—

Methane–Oxygen Mixtures.

$$\frac{CH_4 + O_2}{2528} \qquad \frac{CH_4 + 1\frac{1}{2}O_2}{2470} \qquad \frac{CH_4 + 2O_2}{2322} \quad \text{metres per second.}$$

Ethylene-Oxygen Mixtures.

$C_2H_4 + O_2$	$C_2H_4 + 2O_2$	$C_2H_4 + 3O_2$	
2507	2581	2368	metres per second.

Acetylene-Oxygen Mixtures.

$C_2H_2 + O_2$	$C_2H_2 + 1\frac{1}{2}O_2$	$C_2H_2 + 2\frac{1}{2}O_2$	
2961	2716	2391	metres per second.

It was in connexion with his foregoing determinations of the rates of explosion of hydrocarbons, which were mostly made in Manchester during 1891—1892, that Dixon and his collaborators rediscovered the extremely important fact, first observed by Dalton in 1803—1804 but afterwards long forgotten, that on explosion an equimolecular mixture of ethylene and oxygen yields about twice its own volume of carbon monoxide and hydrogen, in accordance with the equation

$$C_2H_4 + O_2 = 2CO + 2H_2.$$

This rediscovery, reinforced by similar observations by Smithells and Ingle (1892) upon the interconal gases of aërated hydrocarbon flames, and by the experiments of W. A. Bone in conjunction with B. Lean and J. C. Cain on explosions of ethylene or acetylene with less than their own volumes of oxygen, finally laid the dogma of the preferential burning of hydrogen in hydrocarbon flames, which had been unquestioningly accepted among chemists as an article of faith for sixty years previously, thus clearing the ground for modern views of the mechanism of hydrocarbon combustion.

In 1886, while in the middle of his work upon "rates of explosion," Dixon was appointed to succeed Sir Henry Roscoe in the Chair of Chemistry at Owens College, Manchester; and this he occupied until his retirement in 1922, when he became honorary professor at the University, while continuing his researches right up to the day of his death. And it was in Manchester that his powers and life work came to fullest fruition and that his greatest influence was exerted.

Under Roscoe and Schorlemmer the Manchester School of Chemistry had become so famous and dominant in the country that many predicted its reputation would inevitably suffer by the former's supersession by a comparatively young and untried Oxford don. But Dixon's outstanding administrative gifts, his devotion to experimental research, his brilliance as a lecturer, his power of arousing in his students the true spirit of enquiry, and the way in which he always identified himself with the social and athletic sides of the College and University, proved more than equal to the task, so that the reputation of the School continually increased under his leadership. He was indeed the *beau ideal* of a university professor.

When Dixon went to Owens College in 1887, its professoriat included Horace Lamb (Mathematics), Balfour Stewart and A. Schuster (Physics), Osborne Reynolds (Engineering), Carl Schorlemmer (Organic Chemistry), W. C. Williamson (Botany), Milnes Marshall (Zoology), Boyd Dawkins (Geology), Robert Adamson (Philosophy), A. W. Ward (History), A. W. Wilkins (Latin), and Alfred Hopkinson (Law). His own chemical staff comprised Carl Schorlemmer, G. H. Bailey, Harry Baker, J. B. Cohen, and Watson Smith; and a year later G. J. Fowler and A. Harden joined it. It was probably at the time the strongest chemical teaching staff in the country, and the splendid lecture theatre and laboratories which had been built fifteen years previously under Roscoe's supervision were unsurpassed in those days.

It did not take Dixon long to settle down and get to work in such a congenial environment, which powerfully stimulated and developed his scientific and administrative powers. And he soon attracted round him a band of enthusiastic students and workers, with whose co-operation he founded his Manchester School of Combustion Research. His first research asistants were H. W. Smith and G. H. Turpin (1888), followed by W. A. Bone and B. Lean (1891), E. H. Strange and E. Graham (1894), and E. J. Russell (1896), and later by R. H. Jones and L. Bower, all of whom collaborated with him in the experimental work on gaseous explosions during the period 1888—1903, the results of which were ultimately embodied in two *magna opera* in the *Philosophical Transactions* of the Royal Society in 1892 and 1903, as well as in other papers published in the Journal of the Chemical Society between those years.

Before dealing with his Manchester researches, something should be said about his direction and development of its great chemical school. In some respects his start off was not altogether auspicious. For under his predecessor, Roscoe, who for some years (1852—1856) before his appointment to Manchester in 1857 had been closely associated in research with Bunsen in Heidelberg, the school had been steeped in Bunsen traditions, and naturally enough at first some of the old hands did not take very kindly to the succession of an Oxford don who not only plumed himself on having upset Bunsen's conclusions about gaseous explosions, but also had quite other ideas about teaching, and left the supervision of routine laboratory work mainly to his subordinates. This feeling, however, soon died down when they discovered how keen Dixon was upon giving everyone ample opportunities for research, and how great were his gifts as a leader and an administrator. And henceforth he was strongly supported by all concerned, and success was both great and unbroken.

In 1892 his colleague Schorlemmer died and was succeeded by the late William H. Perkin, jun., whose dynamic personality and unrivalled technique infused such new vigour into the organic side of the school that soon its laboratories so overflowed with students and researchers that extension of its buildings and equipment became necessary. The successive addition of the " Schorlemmer," " Schunck," and " Morley " laboratories barely sufficed to accommodate the ever-increasing crowd of workers. Work went on busily day and night during term-time and vacation, throughout the whole year in never-ceasing activity. The fame of it spread into many lands and " fired the heather " throughout the North. The youth of Lancashire and Yorkshire " caught on " and joined up in their scores. There is a spirit in the bleak Northern moorlands—

" *where th'east wind blows snell an' keen* "

—that knows great leadership and " scents battle from afar," and in the 'nineties Dixon and Perkin captured it for chemical science. Although differing widely in temperament, upbringing and outlook, they shared a common enthusiasm for experimental research, gave each other constant and ungrudging mutual support and proved an ideal combination for the development of a great chemical school. In 1913 they were joined in its professoriat by A. Lapworth, who eventually succeeded Dixon on his retirement in 1922. Of their lieutenants and pupils, W. A. Bone, H. C. H. Carpenter, D. L. Chapman, J. B. Cohen, A. W. Crossley, A. Harden, W. N. Haworth, J. W. Mellor, F. L. Pyman, Robert Robinson, E. J. Russell, and J. F. Thorpe subsequently became Fellows of the Royal Society; P. J. Hartog, B. Lean, Norman Smith, and G. S. Turpin achieved distinction in educational affairs; while G. W. Andrew, G. H. Bailey, E. Bury, H. G. Colman, T. Ewan, G. F. Fowler, H. Hartley, D. S. Jerdan, H. Levinstein, R. Lessing, G. P. Pollitt, R. E. Slade, and R. V. Wheeler, to mention a few only out of many, subsequently made their mark in industry and technology.

After completing his work on rates of explosion in the early 'nineties, Dixon's researches (though comprising also the combustion of both carbon and carbon disulphide, as well as further experiments upon the influence of moisture in the combustion of carbonic oxide) were chiefly photographic studies of flame movements in explosions, in which work he had the collaboration of first of all E. H. Strange and E. Graham, and afterwards R. H. Jones and L. Bower. Although the method adopted—namely, that of photographing a horizontally moving flame upon a film moving vertically with known velocity—was in principle the same as had been originated by Mallard and Le Chatelier in 1880—1883, it was so vastly improved and developed in detail as to become a very refined and accurate method of flame analysis. It was first described in a paper "On the Explosion of Cyanogen" communicated to the Chemical Society in 1903; but the memoir embodying the full results thereof appeared in *Philosophical Transactions* for 1903. Meanwhile both Berthelot and Le Chatelier, who had been working on similar lines in France, published papers on the subject in 1899 and 1900.

It is impossible in the short space at our disposal to give any adequate idea of the wealth of information contained in the seventy or more photographs of explosion flames included in Dixon's 1903 memoir; and the only way for anyone to understand their value is to study them closely in detail. Suffice it to say that the whole course of a gaseous explosion, from its initial phase of slow uniform flame movement up to its culmination in detonation was photographically analysed with great precision. Not only were the influences of compression waves and the collision of detonation waves illustrated, but discoveries were made of (i) the backward "retonation wave" which is always set up when detonation is determined in a gaseous explosive medium, and (ii) the "reflexion waves" which arise when a detonation wave is either arrested by the closed end of a tube or momentarily retarded on passing a constriction in it. Similar discoveries were simultaneously made independently by Le Chatelier in France, so that the years 1900—1903 saw a remarkable resuscitation of the interest aroused twenty years previously by the kindred researches of the same masters.

Dixon's third principal line of research which chiefly occupied him after 1903, and in which he was assisted by H. F. Coward, J. M. Crofts, L. Bradshaw, C. Campbell and others, was concerned with the "ignition temperatures" of explosive gaseous media, which he was the first to determine with any real degree of accuracy. Previous attempts, notably by V. Meyer and pupils in Germany, and Emich in Austria, had been frustrated by the considerable amount of pre-flame surface-combustion which always had occurred in their experiments before the explosive medium as a whole had been raised to the true ignition point. To obviate this source of error, Dixon and Coward devised their well-known "concentric-tube" method in which streams of combustible gas and air (or oxygen) were separately heated to the temperature of the medium before being allowed to mix. In this way, the "ignition range" at atmospheric pressure of hydrogen was found to be 580—590° in both air and oxygen, of moist carbonic oxide 644—658° in air and 637—658° in oxygen, of acetylene 406—440° in air and 416—444° in oxygen, and so on. Paraffin hydrocarbons, such as methane and ethane, were similarly found to have much wider "ignition ranges," *e.g.*, that of methane was 650—750° in air and 556—700° in oxygen. Later on, after it was discovered that the earlier results had been affected by the fact that when an explosive mixture is rapidly heated even to its "ignition point" an appreciable "lag" may occur in the actual appearance of flame, the concentric-tube apparatus and procedure were modified so as to control and determine such "lag." In this way it was found that the longer the "lag" allowed, the lower the resulting ignition temperature. Thus, for example, in the case of hydrogen at atmospheric pressure for a "lag" of 0·5 second only the "ignition temperature" was 631° in air and 625° in oxygen, respectively, but on allowing a "lag" of 10 seconds temperatures of 588° and 582° only were required.

In 1906—1907 H. G. Falk, acting on a suggestion by W. Nernst, had endeavoured to determine the ignition temperatures of various gaseous explosive mixtures under adiabatic compression, by compressing them in a steel cylinder the piston of which was suddenly driven in by means of a falling weight. And, finding that with hydrogen–oxygen mixtures the equimolecular required the least degree of compression (corresponding with a temperature of 518°) for its ignition, he concluded that hydrogen peroxide, and not steam, is the first product of the reaction.

Dixon, who never believed in any "peroxide" theory of combustion, at once took up the matter in conjunction with J. M. Crofts, and had no difficulty in proving not only that Falk's experimental method had been faulty in that the piston had not been stopped at the beginning of the pre-flame period but also that two of his assumptions were generally invalid. And on publishing their own experiments in 1914, they had no difficulty in showing that his conclusion regarding the ignition of hydrogen–oxygen mixtures was entirely wrong. They showed that (i) the true ignition temperature of electrolytic gas under adiabatic compression is 526°, and (ii) whereas successive dilutions of it with either hydrogen or nitrogen continually raise, dilutions with oxygen continually depress, the ignition temperature, such depressions continuing long after the $H_2 + O_2$ ratio has been·passed. At the time, this unexpected result suggested to them the formation of some active "polymeride" of oxygen under the experimental conditions; but nowadays it would not be regarded as indicating more than some prior "activation" of oxygen as a prior condition of the combustion.

Dixon continued his work on ignition phenomena right up to the end and further discovered (*inter alia*) that "ignition temperatures" of a gaseous media are, or may be, profoundly affected by the presence of small amounts of impurities therein. Thus he found, for example, that whereas the presence of small quantities of oxides of nitrogen lowers, that of iodine vapour materially raises, the ignition temperature. And it was upon experiments arising out of the action of iodine, which has important bearings upon the prevention of explosions in coal mines, that Dixon was engaged in his laboratory a few hours only before his sudden death at Lytham in the afternoon of September 18th, 1930, thus leaving an " unfinished symphony " for his pupils to complete.

Although Dixon devoted his scientific life to the study of combustion, other problems in inorganic chemistry sometimes occupied his attention. Among them the one which showed a notable advance on any preceding work on the subject was his determination, with E. C. Edgar, of the atomic weight of chlorine (*Phil. Trans.*, 1905, 169). A few years before, Edward Morley had determined, with an accuracy never before approached, the direct ratio of the combination of hydrogen with oxygen. Since very many atomic weights depend on the synthesis or analysis of oxides, Morley's result led to the correction of a large number of these constants. But in 1905 the atomic weights which depended on the analysis of their chlorides were also numerous and the determination of the ratio of hydrogen to chlorine was therefore important. The weighing of chlorine was the great difficulty. It was solved by liquefying the gas in a weighed bulb and weighing it at the ordinary temperature. Since no ordinary glass tap would stand the pressure, the plug always blowing out, Dixon had taps made in which the slope of the plug was reversed, so that the greater the pressure, the tighter was the tap. This ingenious modification enabled a most concordant series of values to be obtained, and it is interesting to note that, after twenty-six years, Dixon and Edgar's number for the atomic weight of chlorine still stands.

Besides being both a great exponent of the experimental method in science and an able administrator, Dixon shone brilliantly as a lecturer, teacher, and master trainer of those who were privileged to be his pupils in research; and it was as such that the influence of his personality was most markedly felt. For he prided himself most on having founded an English School of Combustion Research embodying the traditions of Robert Boyle and Humphry Davy, with whom he ranks in apostolic succession. In writing to one of us on August 26th, 1927, about the publication of " Flame and Combustion in Gases," which had been dedicated to him he said, " I think you know that I regard the chief reward of my work to lie in the fact that when I started fifty years ago to repeat Bunsen's experiments, no one in England seemed to care about the burning of gases, and now there is an active English School largely made up of old students . . . really keen on the fundamental study of gas reactions." And it is worth while considering how this resulted from his work and influence.

First of all, his lectures, distinguished as they always were by great clearness, logical presentment and wealth of experimental illustration, aimed chiefly at expounding principles, as exemplified by the researches of great masters, and at arousing in his students the true scientific spirit of enquiry. One of his most distinguished pupils has recently testified to us that " his account of the classical investigations showed how discoveries were made, the ideas at the back of the minds of the investigators, and the methods whereby they overcame difficulties. Personally, I found this method most inspiring, and far better than any exposition of the results. As he used it, the historic method was a splendid instrument for training research pupils, and it undoubtedly helped all his students." Indeed, no one privileged to hear his lectures could fail to be impressed by the acumen and power of a great teacher.

Next, he had an unusually sound critical faculty and complete mastery of clear exposition in the best and most concise of English. In his earlier days in Manchester, while yet his school was of such dimensions as allowed it, he would get his " first years honours " pupils to write him weekly essays on some subject arising out of his lectures, and in a special weekly tutorial he dealt with their efforts, reading out and criticising passages from them. Each of his " third year " students was required, about twice each term, to write an exhaustive essay upon some subject of the day, after reading and abstracting all the principal researches upon it; and it was Dixon's invariable custom privately to go through each composition with its author, sometimes spending hours even in criticising and discussing it. He never let any weakness in argument, inconsistency in statement, or loose expression go by uncorrected, and was untiring in his efforts to evoke good literary style and habits. Not only so, but on occasion he would ask a senior research assistant to lecture to him on the subject of an essay, in order to train him in its verbal exposition. Many of his pupils owed a great deal to him in these respects.

Lastly, his singularly clear and penetrative mind referred everything to the final test of a well-ordered experiment, critically carried out without hurry or bias, and with the results checked at every conceivable point. He insisted upon everything being done with the greatest care and circumspection, and afterwards subjected to the most vigorous examination. At all times he was unsparing in the guidance of his experience and unrelaxing in impressing on all concerned the paramount importance of accuracy and truth, together with the highest standard of experimental work. He always held that what apparently are the simplest cases of chemical change are fundamentally the most obscure and worth while investigating. His method was first of all to get at the facts with all due precautions against possible errors, then to consider critically their bearing on the matter involved, and to advance the experimental proof step by step, by a process of exclusion, until it had been narrowed down to a single issue which finally had to be tested in every possible way. And, at the end of it all, he would often constitute himself the *advocatus diaboli*, trying his hardest to upset the verdict. Not long ago he remarked to one of us that he had never seen any law or theory relating to flame and combustion which could not either be disproved or shown inadequate, so varied and complex are the possibilities, adding, "I know no law of flame, nor want to." For, eschewing all rash speculation, and attaching little importance to theories save as working hypotheses, the dry light of science shone throughout all his work, and he had a singular felicity in choosing just the right words in expounding it. Being associated with him in research meant, not only having to excel as a craftsman, but undergoing a most exacting mental discipline, which only strong minds could stand; but to them it became the way of understanding.

He always endeavoured to transfer to his teaching staff those of his research pupils and assistants whom he thought most highly of, and to retain them there for some years. Their pay was wretchedly poor, and he did nothing to improve it, regarding it as part of a salutary discipline; but in compensation he arranged the duties so that each one had half his time for research, and was given all possible facilities for pursuing it independently. And he was against anyone accepting a better post outside until research had become his ingrained habit and he had established some reputation as an independent worker. Hard and long as was the discipline, everyone who underwent it was conscious of being handled with real appreciation and understanding, however austerely, and ever afterwards was thankful for it.

From Manchester many of his pupils went forth to plant research colonies in other centres, and in later years he took great delight in visiting them. So keen was his interest, that he would journey any distance to see a new experiment, or correspond at any length about it. In visiting his pupils' laboratories, he would watch everything with a most critical eye, quick to take in every point of an experiment, and to detect the slightest flicker of a flame; but when he had convinced himself of the genuineness of a new result, his appreciation of it was both deep and sincere. At times, on such occasions, he would sit up to well-nigh daybreak discussing the results, and comparing them with his own; and always he gave generously of his experience, whether personally or by letter.

Although Dixon always took an active share (as member of its Court and Council) in Manchester University affairs, and managed his own Department of it supremely well, it would not be easy to point to anything which he specifically influenced except the social and athletic sides of student life, in which he always took the greatest interest, and the work of the Joint Matriculation Board of the Northern Universities, of which he was Treasurer for fifteen years. He was prominent among those who organised the Faculty of Science in the newly constituted University in 1903, after the break up of the old federal Victoria University and the granting of the separate charters to Manchester, Liverpool, and Leeds. It was mainly through his energy that the present splendid University athletic ground and pavilion at Fallowfield were secured.

Outside the University, Dixon played a notable part in the educational affairs of Manchester and Salford. He took a great interest in the Manchester High School for Girls, and in its appendage the Pendleton High School, both of which owe a tremendous debt to him. Also, for many years he was co-opted member of the Salford Education Committee, Chairman of its Higher Education Committee, as well as of its Royal Technical College and some of its secondary schools; all these positions he continued to fill until the end with conspicuous success and great advantage to the public. Latterly he devoted much time to the establishment of the new Queen Mary's Secondary School for girls at Lytham, and was returning from a meeting in this connection at Lytham when he was suddenly taken ill and died.

Dixon was elected Fellow of the Royal Society in 1886, was the Bakerian Lecturer in 1893, served on its Council 1902—1904 and was awarded one of its Royal Medals in 1913. In 1922 the University of Manchester conferred upon him its D.Sc. *honoris causa*, the University of Prague having similarly conferred its Ph.D. some years previously. In view of the outstanding importance of his scientific work it may seem strange that these were the only honorary academic distinctions conferred upon him; but Dixon was markedly indifferent about such honours, and never sought after them.

Dixon joined the Chemical Society in 1876, and contributed his first paper to the Journal in 1885. He was elected to the Council in 1892 and served thereon for a period of twenty-five years in all, occupying the office of President from 1909 to 1911.

He presided over the Chemical Section of the British Association at its Oxford Meeting in 1894, when he delivered a memorable address entitled "An Oxford School of Chemists," in which he charmingly reviewed the work of Robert Boyle and his pupils, Robert Hooke and John Mayow. He was President of the Manchester Literary and Philosophical Society during 1907—1909. He was always ready to serve the public interest. In 1881 he made experiments for the Board of Trade on standards of light to be used in photometry, and three years later he made photometric measurements upon various illuminants at the experimental lighthouses erected by Trinity House on the South Foreland. He served on the Royal Commission on Explosions of Coal-dust in Mines (1891—1894) and on Coal Supplies (1902—1905); also he was a member of the Home Office Executive on Explosions in Mines (1911—1914), and since 1927 acted as Supervisor of Researches on the Ignition of Gases under the Safety of Mines Research Board. During the War he was Deputy Inspector of High Explosives for the Manchester area and Chairman of the Ministry of Labour Selective Committee for the North-Western District, for which services he was appointed C.B.E. in 1918.

Amid his manifold other interests, Dixon never lost his early love of the classics, and while voyaging to South Africa with the British Association in 1906 he produced for private circulation a verse translation of the Odes of Horace, which for scholarly treatment and real feeling could scarcely be surpassed. Indeed, Horace and Omar Khayyám were his favourite authors, and he was filled with the spirit of the "*Novum Organon*," of which his scientific work was the fruit.

As a boy, Harold Dixon was very handsome, his portrait being painted by Thomas Firth, R.A., and his head modelled by Bailey the sculptor, in both cases at the artist's request. Of medium height, with well-knit frame, throughout his life his was an arresting face and bearing in any social assembly. In outward features he bore a strikingly close resemblance to his great contemporary Berthelot, than whom he was twenty-five years younger. Indeed, at one time it was difficult to distinguish the two when they were together.

He was brilliant in conversation, and as an after-dinner speaker; a man of the world, he had much sympathy with the weakness of human nature, but was intolerant of all shams and bores. He had a remarkably equable temperament and *sang froid*, always showing great coolness and presence of mind in time of danger. A story is told how once during 1889 in Manchester when he and his assistant had miraculously escaped injury from the accidental explosion late one afternoon of the content of a 10 cubic foot holder full of electrolytic gas, which wrecked the room in which they were working, some three hours afterwards Dixon went out to a dinner party and on being asked by a lady whether he had heard of "that dreadful accident to a poor professor at Owens College," replied, "Yes, I did hear a report!"

Although Dixon continued to play both cricket and tennis well into middle life, his chief physical recreation was mountaineering, in which he excelled. He climbed much with J. N. Collie and Milnes Marshall, being one of the party when the last-named lost his life on Scawfell on December 31st, 1893. During 1890—1893 he accomplished more than twenty first-class climbs in the Alps, and was elected to the Alpine Club in 1894. Afterwards, in 1897, he climbed in the Selkirks, Canada, making first ascent of both Pollux and the Dome, and the second ascent of Castor, with C. E. Fay and others. Also, in the Canadian Rockies, he made the first ascents of Mounts Lefroy and Gordon with C. E. Fay, Norman Collie, and C. S. Thompson.

Although of a kindly disposition, and always most friendly towards his colleagues and assistants, being ever ready with practical sympathy and help in times of need and trouble (as many have testified), he was singularly reticent about himself and masked his real feelings. It was easy for a colleague or assistant to establish and continue friendly relations with him, but difficult to penetrate within his outer ring of electrons. The experience of one of his Manchester staff who said, "I didn't feel after thirteen years' acquaintance that I knew him any better than after three months," would (we think) be shared by many others. Even to those of us who knew him longest and best, it was rarely (if ever) that he revealed anything of his more intimate self. And while hosts of his old pupils will ever remember him with deep affection and gratitude, most of them will still wonder whether they ever really knew him at all.

He was twice married, first in 1885 to Olive Beechey Hopkins of Montreal, who died in 1917, and by whom he had a son and a daughter; and then in 1918 to Muriel Kinch of Yelverton (South Devon) who survives him, and by whom he had a daughter. All three children also survive him.

His mental powers were maintained quite unimpaired right up to the end, which came suddenly at Lytham on September 18th, 1930. Only a few weeks before, when paying what proved to be his last visit to the laboratories of one of us (W. A. B.) at the Imperial College, London, he spent most of the day seeing and discussing some new photographic experiments on the development of "detonation" in gaseous explosions. He examined the resulting flame photographs intently with all the old critical keenness of his practised eye. The hours sped by almost unnoticed; at last, suddenly looking at his watch, he exclaimed, brushing aside the photographs with a gesture of regret, "All these are most wonderful, my dear boy, but it is now past five o'clock and I must catch my train home, leaving them to you," and so departed. *Vale Magister Praeclare!*

H. B. B.
W. A. B.

WILLIAM ERIC DOWNEY.

1900—1931.

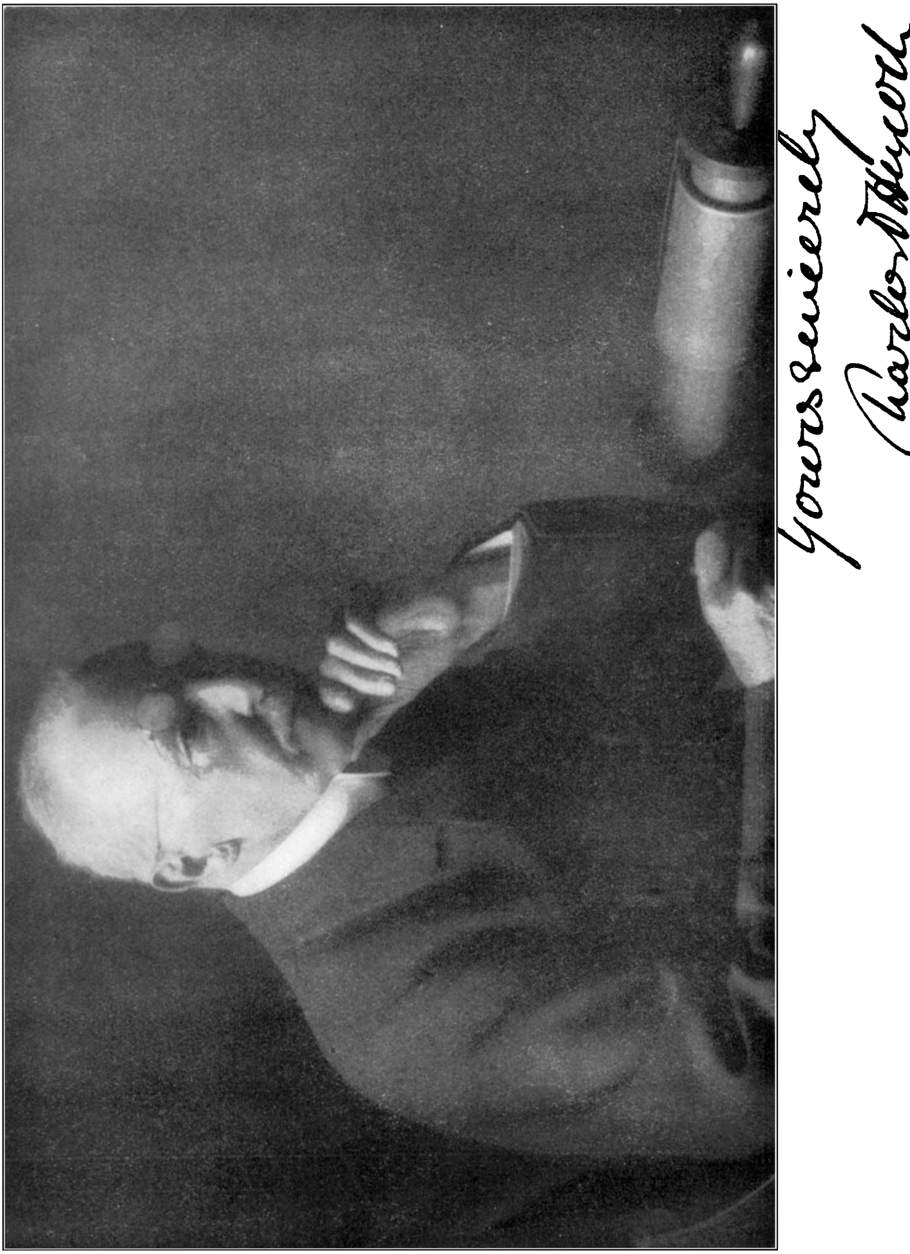
By the death of Dr. W. E. Downey in a climbing accident on the Jungfrau on August 19th, 1931, the Chemical Society has lost a promising and popular Fellow. Downey was 30 years old, and a native of Huddersfield, where he was a student at the Technical College. In 1921 he entered the Imperial College of Science and Technology as a Royal Scholar, working under Professor H. B. Baker on the light emission in the oxidation of phosphorus and its relation to the formation of ozone. The results of this work were published in the Transactions for 1924—1925. The degree of Ph.D. was conferred on him by the University of London in 1923 and he held a Beit Fellowship from 1924—1926. Subsequently, as a member of the research staff of the General Electric Company, he built up a reputation as a research worker of the highest order. Downey was elected a Fellow of the Society in 1926, and his death will be deeply regretted by all.

H. J. E.

CHARLES THOMAS HEYCOCK.

1858—1931.

The death of Mr. C. T. Heycock, which took place on June 3rd, removes from among us one who had gained the affection of generations of Cambridge men and who was a pioneer in an important branch of inorganic chemistry. Heycock was the younger son of Frederick Heycock, of Braunstone, Oakham, and was born on August 21st, 1858; he received his early education at the Grammar Schools of Bedford and Oakham, and entered King's College, Cambridge, as an Exhibitioner in 1877, taking the Natural Sciences Tripos in 1880. For many years he taught chemistry, physics, and mineralogy for the Cambridge examinations and in 1895 he was elected to a Fellowship at King's College, becoming a College Lecturer and Natural Sciences Tutor in the following year. He



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was elected a Fellow of the Royal Society in 1895 and was awarded the Davy Medal in 1920 for his work on alloys. His original work on the metals attracted the attention of the Goldsmiths' Company, who endowed a Readership in Metallurgy at Cambridge; he was appointed to this office in 1908 and held it until his retirement in 1928. He was admitted to the Livery of the Goldsmiths' Company in 1909 and to the Court in 1913; he acted as Prime Warden during the year 1922—1923 and took a keen interest in the work of the Company's Assay Office.

Notwithstanding the exacting character of his work as a Cambridge coach, Heycock joined with his lifelong friend, F. H. Neville, F.R.S., in a comprehensive study of the metals and their alloys; this partnership, which was only dissolved by the death of Neville in 1915, led to a remarkable series of papers in which novel directions of investigation were mapped out and developed. Before entering upon this joint work, Heycock had had some experience as an investigator; in 1876 he published a note on the spectrum of indium in conjunction with Mr. A. W. Clayden, M.A., and in 1882 he contributed a paper on the atomic weight of rubidium at the British Association meeting. Heycock and Neville's first joint paper was published in 1884 and described a redetermination of the molecular weight of ozone by the diffusion method. The first of the series of papers on the metals was published in 1889 and dealt with the depression of the freezing points of metals brought about by others dissolved therein; in this, and later papers it was shown that the addition of small amounts of a second metal depresses the freezing point of the first to an extent (1) directly proportionate to the weight of metal added and (2) in rough inverse proportion to the atomic or molecular weight of the added metal. Raoult's law for ordinary solutions was thus extended to alloys and a method indicated for calculating the latent heat of fusion of a metal by the application to the freezing point depressions of the now well-known van 't Hoff equation. At the outset mercury thermometers were used in the temperature measurements and only alloys of low melting points could be studied; the introduction by H. L. Callendar of the platinum resistance pyrometer made it possible to extend the scope of the investigation to metals of high melting point. At that time the melting points of silver, gold, and copper were not known with any degree of accuracy, partly because of the difficulty of making the physical measurements, partly because the necessity for using metals of high chemical purity and for protecting them from contamination during melting had not been recognised. A number of fixed points on the platinum resistance pyrometer had to be established before the study of alloys of high melting points was undertaken; these fixed points were determined with the aid of Dr. E. H. Griffiths, F.R.S., and with such accuracy that the results obtained by their use have not since been seriously affected. Thus, Heycock and Neville determined the melting point of Levol's alloy at 778·7° C. and used this constant as a secondary fixed point; a very recent determination by the Washington Bureau of Standards gives the melting point as 779·4°.

The study of dilute metallic solutions naturally led up to the determination of the complete liquidus curves of many binary metallic systems, such as those of silver or copper with a second metal; in many of the systems thus explored, the cooling curves of the alloys showed arrest points below the temperature of the solidus. Although Stead and Roberts-Austen had done much to elucidate this subject, the causes of these evolutions of heat were not properly understood. Heycock and Neville therefore turned their attention to the examination of solid alloys and about 1897 began work on the gold–aluminium system, probably choosing this because of its complexity. In this connection they developed a technique for taking photographs through an alloy by means of Röntgen rays. This method yielded some valuable results, but was soon abandoned because it was found that the examination of etched surfaces by the microscope was simpler and more efficient. Their first paper on the constitution of the gold–aluminium alloys was published in 1899 and, though the work was incomplete, contained the first of a remarkable series of photographs. The writers probably recognised that a full description of this system was not at that time within their powers; they set the work aside and started the investigation of the constitution of the bronzes.

The Bakerian Lecture "On the Constitution of the Copper–Tin Alloys" was delivered in 1903 and can be regarded as the foundation stone of modern metallography. Not only was it in itself the first substantially complete and accurate description of a complex series of alloys, but it aroused great interest and encouraged many others to undertake similar work. In spite of the care with which the copper–tin system was examined the diagram given in 1903 is not correct in every detail; its authors had early recognised that stable alloys are often difficult to obtain and, with the object of removing completely any metastable phase, they cooled the preparations extremely slowly from above the temperature of the liquidus. It has since been shown that such treatment frequently fails to produce a saturated solid solution and may, indeed, tend to prolong metastable conditions. Heycock retained his interest in these alloys and during recent years encouraged his students to revise the details of the diagram under his direction.

When the two collaborators had completed their work on the copper–tin alloys they took up again the study of the gold–aluminium system. Here progress was slow because of the inherent difficulties of the problems which arose and because a disastrous laboratory fire had destroyed most of the earlier records; in 1914, however, Heycock and Neville published a classical piece of work on those alloys of this system which are rich in gold. As President of the Chemical Section of the British Association in 1920, Heycock gave an address describing the state of knowledge at the time when he and his friend commenced work and indicating the chief results of their own researches.

The major part of Heycock and Neville's experimental work was carried out in a small laboratory in Sidney Sussex College and, owing to the many other duties which fell upon the two partners, much of it had to be done late at night and in the early hours of the morning. It may seem surprising that such a quantity of data of enduring value could be collected under such conditions; but both men were enthusiasts, both possessed an exquisite sense of technique and both were meticulous in their striving after accuracy.

Heycock was an excellent lecturer; his whimsical mode of addressing a class sustained an interest in inorganic chemistry during a period when that subject seemed in danger of eclipse by the rapid advance of organic chemistry. He had few equals as a teacher in the laboratory; his deliberate method of working and his sarcastic denunciation of slovenliness inspired respect and awakened the spirit of emulation. Much of the work of organising and planning the numerous extensions of the University Chemical Laboratories during the last twenty-five years fell upon him and he carried it out with characteristic care and thoroughness. His physical vigour found further expression in his devotion to the Volunteer movement from quite early days and during the War he was appointed Colonel of the Cambridgeshire Regiment.

In his domestic life, Heycock was thoroughly happy; his house was the meeting place of undergraduates and seniors alike and its cheerful hospitality is a delightful remembrance to vast numbers. With his death we have lost a scientific man of the old type who would spare no pains or time in eliminating error from an experimental observation; many of us have also lost a shrewd and wise counsellor and one of the most staunch and loyal of friends.

W. J. Pope.

CHARLES ALEXANDER KEANE.

1864—1931.

By the death of Dr. Charles A. Keane on September 18th after a few days' illness, there has passed away a man who devoted his life largely to the advancement of chemical science, particularly in relation to technical education. Keane was born in 1864 and after a general education at Mount Vernon High School, Nottingham, he entered the Owens College, Manchester, where he graduated as Bachelor of Science in the Victoria University in 1883. After graduation he spent an additional year at the same College, where further chemical studies were pursued under Roscoe and under Schorlemmer. From 1884 to 1886 he continued his studies first under Emil and later under Otto Fischer at the University of Erlangen, where he obtained the degree of Doctor of Philosophy. Afterwards he obtained the degrees of Master of Science and Doctor of Science, Victoria University.

Keane's teaching career began in 1886 as a demonstrator of chemistry in the University College, Liverpool, where subsequently he was appointed Lecturer in Chemistry. He was also a lecturer and an examiner of the Victoria University. In 1901 he was appointed first Principal of the Sir John Cass Technical Institute, London, which post he relinquished in 1926 under medical advice. His resignation as Principal was a matter of deep regret to all who knew of the valuable work which he had carried out in that capacity for over a quarter of a century.

The Institute and its work constitute a magnificent memorial to his wisdom, foresight and resolution and also his determination to make research the apex of technical education. In this connection it should be mentioned that he contributed a number of papers to various scientific journals and made a much larger contribution to the advancement of knowledge by inspiring the members of his staff and his students to undertake research work.

Keane was greatly esteemed by the scientific societies with which he was actively associated and in some of which he held office. From 1917 to 1919 he was Chairman of the London Section of the Society of Chemical Industry and in 1919 he was appointed Vice-President of the Society of Public Analysts and was elected to the Council of the Chemical Society and also to the Council of the Society of Chemical Industry.

In all his activities, he displayed wide knowledge and sound judgment and those who were privileged to be associated with him will always recognise his distinguished service and remember with real gratitude the friendship and goodwill given by him without reserve.

GEO. PATCHIN.

ROBERT LAW.

1870—1930.

ROBERT LAW was born in Scotland on April 20th, 1870. He attended the College of Science and Arts, Glasgow, and for a time was Assistant there to Professor A. H. Sexton.

Whilst studying at Freiburg, he was recalled to London to sit for an examination for the post of Assistant Assayer in the Royal Mint, Melbourne. He gained first position on the list and was appointed to Melbourne on September 2nd, 1890. He served in the Assay Department, first under the late George Foord and finally under the late F. R. Power. In 1919 he became Chief Assayer and later, under Colonel Johnson's reorganisation scheme, was appointed Chemist and Refiner.

Law was of an inventive turn of mind and in addition to other things devised the preliminary assay balance designed to save time in weighing cornets and diminish wear and tear on assay weights. This is described in Mint Reports 1896 and 1913, and in the Journal of the Chemical Society (1896, **69**, 527).

Law was keenly interested in military matters. Since 1904 he was attached to the 34th Engineers of Victoria, and was C.O. of the Unit until his retirement from the Force in 1929.

During the great war, he was for a period C.O. 3rd Pioneers, A.I.F.; he was mentioned in despatches, and was eventually invalided home.

Law was President of the Society of Chemical Industry, Victoria, for the years 1926—9 and during that time communicated papers dealing chiefly with metals from the aspect of coinage operations. He also published in the Reports of the Royal Mint results of experiments and observations on the chlorine process of gold refining—a subject upon which little has been published in chemical literature.

He was a Fellow of the Institute of Chemistry, a member of the Australian Chemical Institute, and a member of the Institute of Metals.

Law passed away in his sleep on July 22nd, 1930, and the suddenness of his death can be gauged from the fact that he had lectured before the Society of Chemical Industry, Victoria, on the previous Friday and to his colleagues in the Mint had appeared to be in normal health on that day.

Law's work reflected the care he bestowed upon it and will always remain a model to be followed.

F. V. R.

THE RT. HON. LORD MELCHETT, D.Sc., LL.D., F.R.S.

1868—1930.

ALFRED MORITZ MOND, created first Baron Melchett of Landford, was the second son of the famous Dr. Ludwig Mond, F.R.S., and was born on October 23rd, 1868, at Farnworth in Lancashire. His father, after studying chemistry with Kolbe and Bunsen, had acquired much knowledge of chemical manufacture in Germany and had devised a new process for the recovery of sulphur from Leblanc alkali waste. He entered into partnership with John Hutchinson of Widnes to demonstrate this process in England in 1863. After a period spent in the construction and management of a Leblanc soda works at Utrecht, Dr. Ludwig Mond rejoined Messrs. Hutchinson and Company in 1868 and perfected his sulphur recovery process. In 1872 he became impressed with the success obtained in Belgium by Ernest Solvay in the manufacture of soda ash by his improved ammonia-soda process and, obtaining a licence to work this process in England, he entered into partnership with his friend, John Tomlinson Brunner (at that time head of Messrs. Hutchinson's office) to carry out this manufacture on a site by the river Weaver in Cheshire, close to the town of Northwich. Thus was founded in 1873 the famous firm of Brunner Mond, which was converted into a Limited Company with much enlarged capital in 1881. The Brunner and Mond families came to live close to the works, in the beautiful house, Winnington Hall—Dr. Mond living in the more modern part of the mansion, whilst Mr. Brunner lived in the older part. The eight years between 1873 and 1881 were years of tremendous work and stress. Only through the genius, determination, and unremitting labour of the two partners was the enterprise brought to a successful issue. In 1884 Dr. Ludwig Mond took a house in London and from that date onwards made London his headquarters. Thus for the first sixteen years of his life—the important formative years—the boy Alfred Mond saw from day to day the development of a great work and lived in an atmosphere of scientific labour and mighty deeds. It was also an atmosphere of intellect and culture. Dr. Ludwig Mond was a man of the highest intelligence and mental power, and we may be sure that his sons soon learned to value the kingdom of thought and learning as well as that of action and affairs. Throughout his life Dr. Ludwig Mond was deeply interested in music, painting, and literature, so that his sons Robert and Alfred early acquired a knowledge of, and a cultured taste for, all those things which in harmonious combination with science make life interesting, exciting, and beautiful. The intellectual and artistic interests of Dr. Mond were fully shared by his wife, who was a woman of outstanding personality and brilliance of mind. Her influence and guidance must have been a very important factor in the education of her sons.

Alfred Mond was sent to Cheltenham and afterwards to St. John's College, Cambridge. He then went to Edinburgh University for a time to pursue the study of science, but, feeling that laboratory research work was not his natural bent, he turned to the study of law, and became a student of the Inner Temple. He was called to the Bar in 1894 and joined the North Wales and Chester Circuit. Although this study of law must have been very useful to him in his later political life, the practice of that profession did not satisfy his natural leanings towards constructive work and practical achievement: so he joined his father's firm and became a director of Brunner Mond and Co. in 1895. The next ten years of his life were devoted to the mastery of the guiding principles and practical details of the business of large-scale production, wherein he rapidly built up a reputation as an industrialist, organiser, and financier of the highest quality. As is well known, his father had founded (on the basis of his own scientific discoveries) the Mond Nickel Company and the Mond Power Gas Company. As Sir John Brunner stood aside from these enterprises, it fell to the lot of Alfred Mond to take an important share, in conjunction with his brother Robert and his cousin Emile, in the direction and development of these concerns.

It was no idle boast when Mr. Roscoe Brunner (at that time Chairman of the Company) could say at the Jubilee celebrations in 1923 that during the fifty years' history of the firm there had never been a quarrel between the Directors and the workmen of Brunner Mond and Co. The great example that had been set in the early heroic years when Ludwig Mond and John Brunner worked day and night with a valiant band of loyal men, had never been forgotten and had become a continuous policy of friendship and understanding between active and efficient masters and loyal and efficient men. In 1884 Brunner Mond and Co. were the first firm to offer their workmen a week's holiday with full pay in return for good time-keeping, whilst in 1889 the Directors realised that two 12-hour shifts per 24 hours (*i.e.*, 84 working hours per week) involved too great a strain on the men and introduced the system of three 8-hour shifts. This was the friendly atmosphere of mutual understanding, good will, and co-operation which Alfred Mond found when he joined the Company in 1895, and this was the work into which he threw himself with an ardour due fully as much to his kindly and understanding nature as to the keen perception of an essentially modern and forward-looking mind.

When at the General Election of 1906 Alfred Mond (at the age of thirty-eight) was elected Liberal Member of Parliament for Chester, there entered the House of Commons and the arena of political life a man who was not only the bearer of a famous name and the possessor of a commanding knowledge of business and finance, but also one who understood well the necessity and value of scientific research, of organised constructive work in the productive enterprises of the country, and of friendly and efficient co-operation amongst all the varied units of any great industry. A man, in short, who had been for many years in contact with the realities, and understood the essential verities, of modern life in a country whose fortunes were bound up with the science and art of successful manufacture. His exact and varied knowledge and his powers of clear and logical exposition soon gained him the ear of the House, whilst the Liberal leaders found in him a stout defender of Free Trade principles and the rights of His Majesty's faithful Commons. The baronetcy that was conferred on him in 1910 marked their high appreciation of his abilities.

Then came the great ordeal of war. Sir Alfred Mond threw his brains, his private purse, and the resources of all the companies with which he was associated into the service of the country. He was one of the first eminent Liberals to perceive the necessity for conscription, as he was one of the first to foresee the importance of aerial attack. He thrice visited the Front in order to get a clear idea of the needs and conditions of the troops and did everything in his power to help them. He founded and maintained two hospitals, one at Melchet Court, of which Lady Mond was Commandant, and the other at Highgate—the "Queen Alexandra's Hospital for Officers." The great Brunner Mond and Mond factories worked day and night, and at strictly controlled prices, to produce the chemicals required in the war. Enormous quantities of ammonium nitrate were produced, thus rendering it possible for the country to counter the growing and dangerous shortage of toluene by changing over from amatol containing 80 per cent. of T.N.T. and 20 per cent. of ammonium nitrate to an amatol in which these proportions were reversed. At the end of the war Lord Moulton publicly stated that had it not been for the scientific and technical research work and enormous output of the Brunner Mond factories, Great Britain could not have carried on the war.

From 1916 to 1921, Sir Alfred Mond was First Commissioner of Works, and on him fell the responsibility for the enormous building programme that had to be pushed rapidly forward during the war—new factories, Government Departments, Service Headquarters and other things too numerous to mention. From 1921 to 1922 he was Minister of Health and rendered eminent service to the country in putting the national housing policy on a much more business-like basis. Not so well known were his able negotiations with the Trustees of the Rockefeller Medical Foundation of New York, which resulted in the gift to Great Britain of the magnificent Institute for Tropical Medicine and Hygiene which now stands in London between Gower Street and Malet Street, a splendid memorial to American generosity and friendship and to that invincible belief in the value of science for the succour of humanity which infuses the intellectual leaders of that great nation.

It would be inappropriate here to relate in detail the events which led Sir Alfred Mond to break with his old political associates and to join the Conservative Party. It was primarily caused by the launching of a land policy which, to quote his own words, left him " no honourable course to pursue but to break my life-long association with the Liberal Party. I have always believed, and I still believe, that the best interests of British agriculture can be promoted and will be promoted by the free man on his own land rather than the controlled tenant on publicly-owned land. In other words, I remain a convinced and sincere individualist."

Freed from office and the cares of State, Sir Alfred Mond now turned to that reorganisation of commercial production which his keen mind saw was urgently demanded by the changed conditions of the modern world. With all our most formidable competitors forming large combines and cartels, it was clear to him that Great Britain could not expect to meet this new danger while her manufacturers wasted a large part of their energies and wealth in unnecessary competition amongst themselves. In 1923 he began the rationalisation of the South Wales anthracite coal industry, and five years later he had brought 85 per cent. of that industry under unified control. Having succeeded to the Chairmanship of Brunner Mond and Co. on the resignation of Mr. Roscoe Brunner, he set himself to apply the same methods to the " heavy " chemical industry of this country, and together with Sir Harry McGowan he had, by the end of 1926, formed the great combine now known to all the world as Imperial Chemical Industries Ltd. In 1928 he succeeded in combining the International Nickel Co. of New Jersey with the Mond Nickel Co., whilst about the same time he formed the Finance Corporation of Great Britain and America.

Amidst all this vast work of combination and organisation, he never forgot the interests of the workmen, thus worthily carrying on the great tradition established by his father and his father's colleagues. As he had said himself, " In the industry in which I am mainly interested we have succeeded in avoiding for a period of over fifty years any kind of industrial dispute. This has been largely due to a liberal far-seeing policy which did not consist in waiting for claims to be made and then yielding to them reluctantly, but in foreseeing reasonable demands and in granting them even before they were asked. It has been due to a contact, maintained from one generation to another, and to a friendly human spirit between those engaged in various capacities in the industries concerned." It was in the hope of developing and extending these fine principles and traditions that he initiated the meetings and discussions between Trades Union representatives and a selected band of industrial leaders that became known as the Mond–Turner conferences and perhaps marked the beginning of a new era in the industrial history of Great Britain.

In 1928 he was raised to the Peerage as Baron Melchett of Landford, in token of the high esteem in which he was held as a great and far-sighted industrial leader, an eminent servant of the Crown and the State, and a benevolent helper of good causes. The splendid infant welfare centre in Chelsea named after Violet, Lady Melchett, may be cited as one of the many examples of Lord Melchett's wise benevolence.

Dr. Ludwig Mond had amassed during his lifetime a splendid collection of pictures, the best of which were bequeathed to the National Gallery. Lord Melchett was therefore carrying on another family tradition when he surrounded himself with treasures of art, gave many commissions to painters and sculptors, and a few years ago paid £40,000 to keep one of the finest examples of Rembrandt's art in this country.

In 1894, he had married Miss Violet Goetze. Like his father, he had the good fortune to seek and obtain a partner in life who in all his manifold activities—domestic, social, artistic, philanthropic, political—was ever by his side as a brilliant, wise and charming counsellor and devoted wife.

Last, but not least, of the great services which Lord Melchett rendered to his country was his enthusiastic and far-seeing espousal of the economic unity of the British Empire, of an economic League in that great Commonwealth of free and friendly nations. If he had done nothing else, this alone would have marked him out as one of the greatest men of his time. The wise consummation of that splendid ideal constitutes to-day the greatest thing which the British Commonwealth of nations can achieve.

In spite of his continuous occupation with commercial and political affairs of the greatest magnitude, Lord Melchett was ever the true son of his great father. He had a constant and abiding interest in science and scientific research and would break off a conversation on matters of high finance to discuss with evident relish and understanding a new scientific discovery or a new application of scientific principles. As he said himself, he sincerely believed "that the chemist will solve the present economic and industrial problems of the world." He was a strong advocate of University training, not only as a preliminary to successful technical scientific work, but as a necessary preparation for all departments of commercial work. "Highly trained University men," he said, "are required for every part of our business activities to-day. . . . You have to carry the scientific idea through all business." He fostered in every possible way the policy of aiding scientific research in the Universities of Great Britain and thus producing a continuous supply of men well fitted to do their part in the development of the industries of the country.

In recognition of his great services to the State and to Science and Industry, he was elected a Fellow of the Royal Society, thus following in the footsteps of his distinguished father. Honorary degrees were conferred on him by the Universities of St. Andrews and Manchester.

Although the demands made on his time and energies by his manifold activities were very great, he took an active interest in several scientific societies, becoming founder and first President of the Institute of Fuel, President of the British Science Guild, and Pesident-designate of the Society of Chemical Industry for their Jubilee Meeting in 1931—a meeting over which, alas, he was destined not to preside, since he passed away on December 27th, 1930.

Surviving him are his wife, Violet Lady Melchett, one son, Henry, the present Lord Melchett (a Director of Imperial Chemical Industries), and three daughters.

The death of the late Lord Melchett was a severe blow to this country. In such a time of economic stress and necessary reorganisation and reconstruction, he was one of the few men in the country who was pre-eminently fitted, by his inherited gifts, his wide and deep experience, and his vision and imagination, to guide Great Britain and the British Empire across the stormy seas of modern confusion and perplexity to the bright shores of a new prosperity founded on science, organisation, and the imaginative and humane understanding of the varied elements that compose the gigantic structure of the industrial and economic life of to-day. In his patriotism, his foresight and his imagination, he was surely none other than the Disraeli of modern times. When the present sad days are over and the beacons of prosperity and understanding blaze from hill to hill across the lands of the British Commonwealth of Nations, when reason, science, and the understanding heart conspire together to create a new world amongst all men, the name of Alfred Mond will be held in high honour and proclaimed a pioneer of that better and happier time.

F. G. D.

JOHN EDWARD PURVIS.

1862—1930.

JOHN EDWARD PURVIS came up to Cambridge as an undergraduate in 1889 and Cambridge remained his home for the rest of his life—a life spent chiefly in the service of the University and the Town. He was University Lecturer in Chemistry and Physics in their application to Hygiene and Preventive Medicine; he was Councillor, Alderman, and (1928—1929) Mayor of the Borough.

Purvis was born at Heaton Norris, near Stockport, on June 10th, 1862. His father, William Purvis, was a manufacturing engineer.

After attending a day school and the Mechanics' Institute at Stockport, Purvis spent a year at the Owens College, Manchester, and then studied for three years at the Royal College of Science, Dublin. Here W. N. Hartley inspired him with that interest in spectroscopy which he retained throughout his life, and his attention was directed to Cambridge, where Liveing and Dewar were then engaged in their spectroscopical work. In October, 1889, he came up to Cambridge and was admitted a pensioner of St. John's College, which was Liveing's college. He was then 27, and thus considerably above the usual age at entry. He took Part I of the Natural Sciences Tripos in 1891, and Part II in 1893, and was placed in the Second Class in each.

In January, 1894, Liveing appointed him to the official post of Assistant to the Professor of Chemistry and for the next two or three years he was occupied with the fractionation of mixtures of earths of the yttrium and cerium groups. The didymia and erbia which he obtained he used in an investigation of the effects of dilution and temperature on the absorption spectra of solutions of salts of the rare earths and the experimental results were discussed by Liveing in relation to the ionic theory of solution.

At this time the classes in pharmaceutical chemistry for the M.B. degree and the courses of water- and food-analysis for the Diploma of Public Health were conducted by T. H. Easterfield, and when Easterfield left Cambridge to take up the Professorship of Chemistry at Victoria College, Wellington, N.Z., Liveing entrusted this work to Purvis. Purvis, whilst retaining the office of Assistant to the Professor, thus began his connexion with that department of university teaching with which he was afterwards chiefly associated.

On Liveing's retirement in 1908 Purvis's tenure of the office of Assistant lapsed, but it was felt that university recognition was due to him on account of the teaching services which he had rendered. He was appointed University Lecturer in Chemistry and

Physics in their application to Hygiene and Preventive Medicine, and for many years he taught with marked success large classes of medical graduates of Cambridge and other universities who were intending candidates for the Diploma of Public Health.

Whilst he was Liveing's assistant he had occupied a set of rooms on the uppermost floor of the Chemical Laboratory. When he ceased to hold this office he moved into rooms high up over the entrance gateway at Corpus, at which college he was already acting as Director of Studies in Chemistry; these rooms were his home for the rest of his life.

After his work on the absorption spectra of rare earths, carried out for Liveing, Purvis began a series of independent investigations on the Zeemann effect and during the next four years he was engaged in examining the effects of strong magnetic fields on the spark spectra of a number of metals. He detected series of lines which were similarly affected and found an empirical relation between the separation of the lines and the inverse square of the wave-length, but the time was not yet ripe for the fuller interpretation of his observations.

At this time his colleagues Sell and Dootson were engaged on their investigations on the chlorination of pyridine, and Purvis photographed the absorption spectra of various compounds which they had obtained. These experiments formed the introduction to the long series of investigations on the absorption spectra of organic compounds with which his name is associated.

Probably his most important work is that dealing with the absorption spectra of organic compounds in the gaseous state. Research in this field was started by Hartley and others, but Purvis undertook a systematic enquiry into the subject. His first results were of great interest, for he found that many of the narrow bands of pyridine vapour disappeared in the spectra of the homologues. He next showed that a spectrum of narrow bands is exhibited only by the simplest members of a series, such as aniline, phenol or formaldehyde, and that the substitution of methyl groups or halogen atoms (iodine being the most effective) for hydrogen atoms causes the narrow bands to coalesce and form usually only one or two broad bands similar to those observed in solution. Pure liquids examined in the form of extremely thin films were found to give absorption spectra similar to those of solutions. The conclusion which Purvis drew from these investigations was that the absorption of light originates in certain oscillation centres which in most cases are the unsaturated groups in the molecule, and he showed that, whereas chloral has a marked absorption band, chloral hydrate is remarkably transparent, and similarly, while formaldehyde vapour is marked by an extensive system of fine bands, its aqueous solution shows no selective absorption. Methylal, acetal and paraldehyde were similarly found to be non-selective, the view that the absorption of aldehydes is centred in the carbonyl group thus being confirmed.

An unexpected result, and one of considerable theoretical importance, was found with piperidine. Solutions of fully saturated substances give no selective absorption in the ultra-violet region, and piperidine conforms to this rule. But in the vapour state he found that it gave many bands similar to, though less sharp than, those of pyridine. This observation suggested that some groups, saturated in the ordinary sense, such as the NH– group, may act as weak oscillation centres. Some observations were also carried out (with N. P. McCleland) on the interaction of oscillation centres, in particular the carbonyl and the phenyl group and the ethylenic bond, from the results of which an attempt was made to extend Drude's equations to coupled vibrations, the coupling being effected through the kinetic and not the potential energy. These attempts appear crude in the light of more recent knowledge, but they are of interest as an early search for a method of attack which has given valuable results since the discovery of wave mechanics.

The importance of Purvis's contributions to the study of spectral absorption lies in the accuracy of his observations, and later workers are able to utilise his data with confidence. The increasing theoretical importance of a knowledge of band spectra is now commonly accepted, and Purvis's investigations point the way to lines of profitable enquiry. While he confined himself to the older method of displaying his results, his measurements form the starting point for further investigations into the absorption spectra of the compounds studied by him.*

Purvis spent much time and energy, especially in the latter part of his life, in the service of the Borough Council. His connexion with that body began when, in 1908, he was elected a borough councillor by the representatives of the Colleges and Halls. He was made a University Alderman of the borough in 1925. His knowledge of chemistry and hygiene, coupled with his administrative ability, made him a particularly useful member of the Sewage Disposal and Public Health Committees, of the former of which he was for a number of years Chairman, and he rendered valuable service in connexion with the management of the sewage farm. His election as Mayor of the borough took place in November, 1928. However, symptoms of high blood pressure appeared and his health broke down under the strain of office and it was only seldom

* This outline of Purvis's spectroscopic work is based on an account for which the writer is indebted to Dr. J. J. Fox.

and for brief spells that he possessed his full vigour. Nevertheless he carried on, and the members of the town council did not realise how ill he was until a meeting near the end of his mayoralty. He died on November 1st, 1930.

He had a quick temper and a lively sense of humour; shortly before his mayoralty he convulsed the Borough Council with a mock speech as a committee chairman. He was a member of the Cambridge Rotary Club and a frequent visitor to the rooms of the Y.M.C.A. He had a deep religious sense. He bequeathed a considerable sum to the governing body of Corpus Christi College for the provision of a prize, or exhibition, in theology and he left the residue of his property to Westcott House Clergy Training School at Cambridge to found a professorship or lectureship in Christian Apologetics.

W. H. M.

HENRY DROOP RICHMOND.

1867—1931.

Henry Droop Richmond was educated at University College School and Finsbury Technical College. After a period of training in the laboratory of the public analyst, Otto Hehner, he was appointed second chemist in the Khedivial Laboratory at Cairo. From 1892 to 1915 he was chemist to the Aylesbury Dairy Company and published many original papers on the analysis of milk and milk products. During this period, he wrote his book on Dairy Chemistry, which became a standard work. He was appointed Chief Analyst to Boots Pure Drug Co. Ltd. in 1915 and held this post until his death. In this capacity he devised and published many new methods for the analysis of drugs, a method for the assay of saccharin being of special importance.

Richmond became a Fellow of the Chemical Society in 1887 but only published a single paper in the *Journal*, his numerous original papers being mainly published in the *Analyst*. He was a former Vice-President (1909 and 1914—1915) and Treasurer (1910—1912) of the Society of Public Analysts, and was also a former Vice-Chairman of the Nottingham Section of the Society of Chemical Industry (1922—1924). He became a Fellow of the Institute of Chemistry in 1887 and served on its Council from 1906 to 1909 and from 1910 to 1913.

Throughout his career Richmond was distinguished by his willingness to help his younger colleagues in every possible way, not only to guide their professional careers but also to stimulate their social and sporting activities. His kindly disposition remained unclouded to the end in spite of a painful illness of many years' duration.

F. L. P.

THOMAS BARLOW WOOD.

1869—1929.

THOMAS BARLOW WOOD was born on January 21st, 1869, at Habberley, Shropshire; from his father he inherited a long connexion with the land and from his mother the technical and business capacity of a line of Staffordshire potters. He was educated at the High School, Newcastle-under-Lyme, and proceeded to Gonville and Caius College, Cambridge, with a Scholarship in Natural Science. He laid the sound scientific foundation of his subsequent work in his Degree in Natural Sciences and with First Class Honours in Chemistry in June, 1891: in September he began his teaching in Agricultural Science in Devonshire, where the first experiment in agricultural education by means of University Extension Lectures was just being made, and in 1892 he was appointed the first Agricultural Science Master at the Norfolk County School and placed in general direction of the other Agricultural Education activities in the County.

In 1892 the late Professors Liveing and McKenny Hughes started the organisation of a School for training in Agricultural Science and on the death of the first Lecturer in 1894, Wood was called back to Cambridge to take up the duties of lecturer in Agricultural Chemistry.

Under Wood's influence the School began to make progress and in spite of the calls on his time and very inadequate financial support, he carried out experiments and research which attracted the attention of progressive farmers, who began to send their sons to study under him. His interest at that time lay rather in the direction of chemical problems such as the changes which take place in mangolds during storage, the nature and causes of "strength" in wheat, the composition of varieties of mangolds, the increase in crops relatively to the heavy rations of oil cakes used at the time for fattening beasts in Norfolk, and the application of statistical methods for the determination of "experimental error" in field experiments; he also carried out a series of experiments in animal genetics. Any one of these researches showed his rank among investigators and all have become classics.

In 1899 an opportunity was provided by the Drapers' Company for the foundation of a Professorship in Agriculture, and Wood supported the appointment of Professor Somerville; on Professor Somerville's resignation, Wood decided again to put aside his own claims and to support Professor Middleton; Wood was appointed Reader in Agricultural Chemistry in 1902 and on the appointment of Middleton to the Ministry of Agriculture, Wood's claims could not be again passed over and in 1907 he was appointed to the Drapers' Professorship.

By this time the progress of Biochemistry and the results of Kellner's work drew his main interest again to the solution of problems in animal nutrition with which his father's settlement in Norfolk had kept him constantly in touch. He was one of the first to draw practical attention to the view that the processes of life and growth might be considered as the sum of requirements for maintenance, work, fattening and milk production and the consequent calculation of rations to suit each case. During the War, Wood placed himself at the service of the Food Production Department of the Government and it was largely due to his advice on food values that the rationing scheme was so successful and that much tonnage was saved for essential supplies by the importation of finished products in place of raw materials. His study of methods of food production led him to investigate the possibility that for this country the most economical use of cattle would be in the production of milk and baby beef, so saving a large proportion of a year's keep for each beast fattened.

After the War the Ministry of Agriculture recognised his services by placing him in charge of the new Research Institute in Animal Nutrition and he was able to pursue his investigations by means of a specially simple form of animal calorimeter by which, with the assistance of Mr. Capstick, he was able to establish the facts of basal metabolism. After spending much time in an examination of feeding results for sheep, he tried further to solve the interesting problem of giving numerical values to the different vital processes of the living animal, and his last great research was on the subject of the feeding value of pasture grasses at different stages of their growth and cutting.

Throughout all this he devoted himself to the educational needs of the farming community and with the assistance of Professor Biffen succeeded in building up the School to high reputation and efficiency and in overcoming the early antagonism of the University to what was then held to be the establishment of a branch of technical education.

Just before his death the assistance of the Rockefeller Trustees brought into sight the realisation of his dearest ambition, the foundation of a comprehensive research scheme for all problems of farm animal life.

Though Wood excelled in many outdoor sports, his interest in his work and his farm excluded most other activities and he could hardly be persuaded to take a holiday which was not concerned with agriculture. He, himself, was able to investigate and try out suggested improvements in seeds and new feeding stuffs and bring any improvement to the immediate notice of the farmer; he was also in constant touch with men dealing with large-scale practical problems.

Later, after his marriage to Margaret Isabel, second daughter of Mr. E. S. Beaven of Warminster, he allowed himself some holidays, though they were still generally initiated by demands for his advice.

Wood possessed a tremendous fund of energy with which he succeeded in infusing his helpers and in earlier days, when little money was available for his assistants, among whom may be mentioned Foreman and Berry, he gave himself little rest. Later he was able to obtain more assistants, among whom were included Halnan, H. E. Woodman, and Deighton, who were continually under his own supervision, so that he had not much time for recuperation.

During his whole tenure of office he was in continual touch with all the details of the school and was always prepared to hear and discuss any difficulty which might arise with the staff or outside enquirers. He also increased the debt of Scientific Agriculturists by starting the *Journal of Agricultural Science*, of which he for long acted as chief editor.

The end came suddenly, but he had the satisfaction of having gained an international reputation for the school he practically founded and for which he had lived; he himself will always rank with the great investigators of agricultural problems.

R. H. A.