OBITUARY NOTICES.

ARTHUR PILLANS LAURIE.

1861—1949.

ARTHUR PILLANS LAURIE, the eldest son of the late Professor Simon Somerville Laurie, LL.D., the first Bell Professor of The Theory, History, and Practice of Education in the University of Edinburgh, was born in Edinburgh on November 6th, 1861. He was educated in his native city, first at the Academy, and then at the University (B.Sc., 1881), proceeding later to King's College, Cambridge, of which he was an exhibitioner and prizeman. In 1884, his name appeared in the list of first class Honours of the Natural Sciences Tripos (Chemistry), together with several others, afterwards to become well known in various branches of science. He was elected into a Fellowship of his College in 1888.

About this period, Laurie made the acquaintance of Holman Hunt, whom as time went on he came to know very well. The Pre-Raphaelite master encouraged him to study the scientific aspects of painting, and thus in effect spread out before him the pattern of his life's work. Then, in 1891, Laurie contributed a paper to the Society of Arts Journal entitled " On the Durability of Pictures Painted with Oils and Resins," which won him the Society's Silver medal; in the same year he delivered the Cantor Lectures before the same Society under the title " The Pigments and Vehicles of the Old Masters." Further contributions to the Society's Journal on cognate subjects appeared in 1892, 1893, 1907, and 1922. To read these in retrospect to-day is to realise that they represent the work of a mind of somewhat unusual character, at once versatile and original. Pathfinder and seer, Laurie has not laboured in vain.

Wide interests continued to dominate his busy life. In 1895, he became Lecturer in physics and chemistry at St. Mary's Hospital Medical School, and later was appointed an Examiner for the Royal College of Physicians, and for the City and Guilds Institute. The Home Office Committee on Pottery Manufacture also claimed him as a member. Always interested in educational matters, he was Assistant Commissioner to the Royal Commission on Secondary Education in 1895, and in 1900 accepted the Principalship of the Heriot–Watt College in his native capital. Twelve years later, he added to his responsibilities the Professorship of Chemistry in the Royal Academy of Arts. The first of these appointments he held for 28 years, and the second for 24 years. Meanwhile, in 1895, he had obtained the degree of D.Sc. (Edinburgh), for a thesis entitled " The Constitution of Alloys."

The war of 1914—18 found Laurie in constant request, largely on account of his acquaintance with the late Earl Lloyd George who appreciated the value of his capacity for swift experimentation and breadth of technical experience. He served on numerous Bodies connected with supply and inventions, as well as being concerned with Building Research, to which reference is made later. Running through all these activities can be perceived the influence of a sound " classical chemistry; " his training and outlook supplied the basis for what an earlier generation would have called " experimental philosophy," which Laurie knew instinctively how to apply to the problems at issue.

Between the two wars, Laurie gave much attention to the possibility of using ethyl silicates as stone preservatives; in particular his work on silicon esters should be mentioned. He was a member of the Stone Preservation Committee of the Building Research Board, and then, from 1926—1930, of its Standing Chemical and Weathering Committee. Earlier he had published several papers on stone decay. He conducted experiments at Hampton Court and elsewhere in collaboration with the Ancient Monuments Department of the Ministry (then the Office) of works. In favourable circumstances silicon esters enable the stone to be hardened and consolidated without the introduction of a soluble salt. Later developments have been in other directions, but it is probable that they owe much of their value to Laurie's pioneer interest in ethyl silicates.

Laurie's published work covers an extensive field. His output of books alone is impressive, as the following resume will show—" The Food of Plants " (1893), " Processes, Pigments and Vehicles " (1895), " Greek and Roman Methods of Painting " (1910), " Materials used in the Painter's Craft from the Earliest Times to the End of the XVII Century " (1911), " The Pigments and Mediums of the Old Masters " (1914), " Painters' Methods and Materials " (1926), " Simple Rules for Painting in Oils " (1934), " Pictures and Politics " (1934), " New Light on Old Masters " (1935), and " The Technique of the Old Masters " (1949).

In addition to these volumes, several of them of considerable size and scope, Laurie contributed on various occasions to the usual scientific periodicals. He became interested in the way in which the refractive index of paint media in pictures might serve as an indication of the picture's age. (It is, of course, well known that the medium becomes progressively more transparent with the passage of time; it is this effect which is mainly responsible for the appearance of *pentimenti.*) In 1937 he discussed the sorption of organic liquids by raw linseed oil and stand oil films, and the anomalous results to which it gave rise in the study of the refractive index of such films.

Less known in this country are the articles which Laurie wrote for " Technical Studies in the Field of the Fine Arts " (1933—1942), issued by the Fogg Art Museum, University of Harvard, U.S.A. The following is a complete list, in chronological order :

The Use of an Emulsion as a Painting Medium	1933
Examination of the Masks of Mummified Bulls	1934
Notes on the Medium of Flemish Painters	1934
Materials in Persian Miniatures	1935
Problems connected with the Cleaning and Preservation of Pictures	1935
The Microscopic Examination of the Surface of a Picture	1935
Restrainers and Solvents used in Cleaning Old Varnish from Pictures	1935
The Yellowing of Linseed Oil	1936
The Fayum Portraits Painted in Wax	1937

" Auld Reikie " contributed her garlands as the years went on, the Royal Society of Edinburgh its fellowship in 1885, and the University the honorary degree of LL.D. in 1929. Laurie also became an Honorary Royal Scottish Academician.

He died at Haslemere, Surrey, on October 7th, 1949, and is survived by his only daughter, who shared his life and interests through many years.

He was elected a Fellow of the Chemical Society in 1886.

F. I. G. RAWLINS.

SIR HENRY MIERS.

1858—1942.

FEW Fellows of the Chemical Society can have had a more active, a more varied, and a more useful life than Henry Miers. Save for failing eyesight he never grew old, and for nearly sixty years his alert, tireless, keen, smiling little figure was never idle, ever ready with help and advice, whether it was in the British Museum, Oxford, London, or Manchester. He had many interests, but it was his interest in human beings, his genius for helping others to shape their lives, that so many of us remember with gratitude. Perhaps that is not surprising in the great-grandson of Francis Place, one of the great social reformers of the early nineteenth century, the joint founder of University College, London, and a pioneer in adult education. Miers was proud of his ancestry. His father was a distinguished civil engineer, his grandfather, also an engineer, had travelled widely in South America and in 1843 was elected to the Royal Society for his botanical studies. Miers had an elder brother, Edward John Miers, who was a zoologist on the staff of the British Museum. So science and education were in his blood.

He was born at Rio de Janeiro on 25th May, 1858, and two years later his father retired from his South American business and settled in South London. Miers' preparatory school was Summerfields, just outside Oxford, where that skilful teacher Mrs. Maclaren gave him a taste for classics which lasted all his life. In 1872, like so many of his schoolfellows, he won an Eton scholarship. In his five years at Eton he remained true to classics, eventually winning a classical scholarship at Trinity College, Oxford. However his interests were widening in mathematics and science, and on going up to Oxford in October 1877 he read for both Classical and Mathematical Moderations. He had intended to take both the Honours Schools of Mathematics and Physics, but he was getting interested in crystallography, and hearing that there would soon be a vacancy in the Mineralogical Department of the British Museum he decided to throw up his Science School and devote himself entirely to the competition for that post.

Story Maskelyne was then Professor of Mineralogy in Oxford, but he was also a Member of Parliament living in London; he had no Department and lectured only when required. Miers was his only pupil, but Maskelyne came up each weekend to lecture to him, though the lectures soon degenerated into armchair discussions at the home of the witty Professor of Geometry, Henry Smith, who took a lively part in the talks. What could have been more stimulating for a young and enthusiastic undergraduate ?

After taking the Final School of Mathematics, Miers went for three months in 1882 to work in Strasbourg with Groth, with whom he formed a lifelong friendship. The work for his first published paper on cerussite was done during the visit. After all this careful preparation Miers came out top in the Civil Service examination, the only serious competitor being Sanderson, the future headmaster of Oundle.

In October 1882 Miers entered on his new duties at a fortunate moment. The mineral collection had just been moved from Bloomsbury to its fine new quarters in South Kensington, and the new Head of the Department, Lazarus Fletcher, was a kindred spirit who appreciated the fine qualities of his new assistant. Miers helped in the rearrangement of the collection, but he had ample time for research and he took full advantage of the material available for investigation. He remained at the Museum till 1895, and during those years he contributed a long series of papers on the morphology of various crystal species. By them he proved himself an accurate, painstaking investigator, with a quick eye for any abnormality of habit and for points of special crystallographic interest. His most important work was with G. T. Prior on the red-silver minerals, in which they cleared up the relationship of pyrargyrite, xanthoconite, and rittingerite and discovered a new species which was named sanguinite. Although his problems were mainly crystallographic, Miers quickly became a first-class mineralogist. Minerals appealed to his aesthetic taste, he had a wide knowledge of their occurrences and associations, and he was never happier than on mineralogical excursions in Cornwall and elsewhere.

However in spite of the opportunities for research the life of an assistant at the Museum did not for long satisfy the humanism of one who had such a variety of cultural interests. He always longed to be a teacher, and, at the invitation of Arthur Hugh Clough, he gave evening lectures on experimental science, at a neighbouring Board School, to elementary school children. In 1886 his real chance came when H. E. Armstrong, by a stroke of genius, asked him to teach Crystallography in the City & Guilds Technical College. He worked there after Museum hours, and soon built up a small Crystallographic Department which, with the exception of Cambridge, was the first of its kind in this country. Miers' most distinguished pupil was W. J. (afterwards Sir William) Pope, who succeeded him as lecturer in 1895. Pope's first paper was published jointly with Miers, and his early interest in crystals coloured much of his subsequent research.

Miers' energy found many other outlets—foreign travel, visits to most of the great continental mineral collections, and collaboration in a book on " The Soil in Relation to Health," the result of his intimacy with a number of young doctors. His interest in ballooning nearly cost him his life. An aeronaut named Simmons had advertised a balloon flight to Austria, and offered to take one or two passengers. Miers got a few days' leave from the Museum and without telling anyone where he was going he flew off from the Danish Exhibition with Simmons in his large new balloon; the other passenger was a young man named Field. As the wind was from an unsuitable direction Simmons decided to descend for the night near the coast. A strong wind was blowing, and while anchored to a tree near Maldon the whole balloon blew to pieces, and the wire basket with the occupants fell sixty feet to the ground. Simmons was killed, Field broke both legs, Miers was picked up unconscious, and it was six weeks before he could go back to work.

In 1895 came the most spectacular event in his scientific career. He was at the meeting in Burlington House when Ramsay announced the discovery of argon by Lord Rayleigh and himself. The same night Miers wrote to Ramsay suggesting that he should examine the gas given off when cleveite is heated with dilute sulphuric acid, which Hildebrand had thought to be nitrogen. He told Ramsay where he could get the mineral, and six weeks later Ramsay sent the gas from cleveite to Crookes, thinking it might be krypton for which he was looking. Crookes telegraphed back " Crypton is helium. Come and see it." Towards the end of his life an old friend was congratulating Miers on his long innings, saying that in giving the clue to the discovery of helium he hit the ball over the pavilion. Miers replied with characteristic modesty " Oh no ! The helium episode was only a timid but lucky swipe which happened to sneak through to the boundary."

Later in the year Miers was appointed to the Waynflete Professorship of Mineralogy at Oxford in succession to his friend and teacher Story Maskelyne, and in 1896 he was elected a Fellow of the Royal Society. He was delighted to return to Oxford, where he had spent four happy years as an undergraduate, with the prospect of creating a research school of Mineralogy, and with long vacations for foreign travel. The Professorship carried with it a Fellowship of Magdalen, and for thirteen years he gathered round him an ever-widening circle of friends, whom he loved to entertain in his rooms in the New Buildings overlooking the Deer Park.

The rooms in the Museum assigned to the Professor were quickly converted into small but well equipped laboratories for teaching and research, and it was not long before Miers had a small group of keen students. He was an admirable lecturer, and however small the audience Miers gave of his best. Clear and simple, stimulating and full of interest, each lecture was a well-rounded exposition of some topic, which sent us away feeling that for the moment at any rate we understood. I remember as a schoolboy the thrill of hearing his Cantor Lectures on Gem Stones.

Everyone who came under his influence was attracted by his personal interest in them and the happy gift he had of suggesting some subject for research that was within their competence. Among his students were Herbert Smith, who went to the British Museum, H. L. Bowman, who succeeded him in his Chair, T. V. Barker, whose untimely death was a great loss to crystallography, Jacques Chevalier, later Professor of Philosophy at Grenoble, Noel Ashcroft, afterwards President of the Mineralogical Society, and his two assistants R. C. Spiller, now Reader in Mineralogy at Oxford, and R. P. D. Graham, now Assistant Professor of Mineralogy at McGill, who writes of him :

" He was a man of great kindliness, possessed of infinite patience and a disposition that refused to be ruffled. In all the years I was associated with him, I do not recall a single occasion on which he complained, or was impatient, or expressed displeasure when things went wrong or mistakes were made, which doubtless was often enough. Instead, there was always an explanation of the cause of the trouble and instruction as to how it might be avoided in future. These characteristics, and a genuinely personal interest in his students, explain his success as a teacher, for, in his lectures, each individual was made to feel that it was he, personally, who was being addressed. His " Mineralogy," first published in 1902, well illustrates his lucid and systematic method of teaching. It unquestionably set a new standard for textbooks of mineralogy and crystallography. Several that have been published since that time are quite obviously modelled on Miers, and one or two may even be said to mirror it, though in much distorted fashion. But in nearly forty years of teaching experience, the writer has failed to meet with a better ' Introduction to Mineralogy ' than that given us by Miers."

Miers' most important work at Oxford had its origin in his earlier crystallographic papers when his accurate measurements so often showed the existence of differences in interfacial angles even on the same crystal which were much larger than the errors of observation. Previous attempts to elucidate the problem of these " vicinal " faces by elaborate series of measurements on mineral crystals had been unproductive, and Miers decided that the most helpful method of attack was to measure the angles of crystals actually growing in solution. For this purpose an inverted goniometer was built by Troughton & Sims with which the angles of growing crystals could be measured, including the small angles between a group of vicinal faces by means of a new form of micrometer eyepiece. Most of the work was done with cubic crystals (the alums and sodium chlorate) as there was then no doubt as to the theoretical values of the interfacial angles. The experiments showed that crystal growth under these conditions takes place on groups of vicinal faces inclined at small angles ranging from 3′ to 20′ to the cubic or octahedral face under examination. A few crystals belonging to other systems were examined and the same phenomenon was found. During the growth of a crystal sudden changes occurred in the inclination of the vicinal faces. These changes always occurred *per saltum* and not continuously, showing that new plane crystal face had come into existence, and that growth did not give rise to curved faces. There were indications that the inclinations to the normal face increased with increasing concentration, but the experiments were not definite on this point.

The results thus justified Miers' intuition that the study of growing crystals was the best way of advancing our knowledge of vicinal faces, as, without knowledge of the whole history of the growth of a crystal, measurement of its final condition might lead to quite erroneous conclusions.

Miers pointed out that the vicinal faces correspond to a much more open packing of the molecules than the normal faces, and that as the molecules are much more densely packed in the crystal than in the solution (45 times in the case of alum solution) it might be easier for the molecules to be deposited in the more open layers. Miers' paper was a most enlightening contribution to a problem that had puzzled generations of crystallographers, and one wishes that he had pursued it further and by growing crystals under carefully controlled conditions had investigated the factors that cause the variations in the vicinal faces. His attempts were, however, diverted to another aspect of crystal growth. He determined the concentration of the solution in contact with the growing face by using the crystal as a prism to measure the refractive index of the solution. This involved the determination of the effects of temperature and concentration on the refractive index of the solution. In the course of the measurements Miers and Miss Florence Isaac, who joined him in the investigation at this stage, found that the refractive index of a cooling solution increased rapidly until a few crystals began to form, and that at a later stage the refractive index fell rapidly as a cloud of crystals was suddenly produced. I found them one day in the laboratory rather puzzled by this, and suggested that these effects might be due to the transition of the supersaturated solution from the metastable to the labile state as predicted by Ostwald. Trials made by cooling aqueous solutions in sealed tubes showed that crystallisation did not occur spontaneously until a considerable degree of supersaturation was reached, the metastable region being represented by the area between the solubility curve and the curve which Miers named the supersolubility curve, showing the concentrations at which spontaneous crystallisations take place.

Together with Miss Isaac, he undertook a number of investigations of the conditions under which spontaneous crystallisation occurred both in aqueous solutions and also in mixtures, as he thought this was of importance in throwing light on the crystallisation of igneous magmas. With Jacques Chevalier too he investigated the differences in the growth of crystals in the metastable and labile regions.

Another outcome of this work was Miers' interest in the effect of one species in affecting the deposition of others which led to the comprehensive study by T. V. Barker of parallel overgrowths resulting in the discovery of a number of interesting relationships.

Miers made full use of the Long Vacation for foreign travel. Visits to the United States and Canada, and then to Russia to learn the language, were followed by an adventurous trip to Klondyke in 1901 at the invitation of the Canadian Government. In 1903 he went to South Africa at the invitation of the Rhodes Trustees to look into educational problems, and again two years later for the British Association meeting at Johannesburg, when he was President of the Geological Section.

Oxford soon discovered in Miers a most valuable recruit for University business. His equanimity, wide interests, and readiness to help, and his untiring energy were a great asset to the University. As Secretary to the Museum Delegates he took a very active part in the administration of the Museum. Most of the stone capitals had been carved by the brothers O'Shea under Ruskin's supervision, but some were still unfinished. Miers found a benefactor with whose help the remainder were carved with floral designs following the original tradition. He served as a delegate of the University Press, a member of the Hebdomadal Council, and as Junior Dean and Vice-President of Magdalen, while at the same time he had many duties in London as Editor of the *Mineralogical Magazine*, President of the Mineralogical Society, and Vice-President of the Chemical and Geological Societies.

It was Miers' constant touch with the outside world that made him a particularly valuable member of the University. But as a result his reputation as an administrator got abroad, and in 1908 he was invited to succeed Sir Arthur Rücker as Vice-Chancellor of London University. Miers felt it was his duty to go although he hated giving up his teaching and research. He had often said that he wished to make way for younger men and was afraid of the stagnation of advancing years in Oxford.

He went to London at a difficult moment. The University was divided and unsettled by the strong antagonisms between the external and internal parties, which were intensified by the fact that Lord Haldane's Royal Commission on the University was sitting and taking evidence. Miers' time was largely taken up by meetings of Councils and Committees. He was a member of the Governing Bodies of all the constituent Colleges, and there were innumerable problems to be faced. Miers had very happy relations with Lord Rosebery, the Chancellor of the University, and his unbiassed Chairmanship of the Senate was a great help at a difficult period. In 1912, the year he was knighted, Miers, against considerable opposition, persuaded the Universities of Great Britain to hold a Congress of the Universities of the Empire in London. This led to the foundation of the Universities Bureau and to future quinquennial meetings of the Congress.

In London Miers missed more and more the close personal relations with students, and when the war came he saw that the recommendations of the Haldane Commission might not be implemented for many years. So in 1915 he accepted an invitation to go to Manchester as Vice-Chancellor, as he felt he might be more useful in a smaller University, particularly as he was also to be Professor of Crystallography and to do some active teaching.

It was a successful experiment, and Miers spent eleven very happy years in Manchester. His modesty, his friendliness, his range of interests, and his charm as a guest or host quickly won the hearts of the Lancastrians. He threw himself into their problems, not only at the University but in the intellectual life of the community, and he did a great work in bringing the City and the University much closer together. He became the social focus of the University, and he gave both to its graduate and undergraduate life a more closely knit personal structure, which is much more difficult to achieve in " Red Brick " than in one of the older residential universities.

It was not an easy time for a Vice-Chancellor. First he had the war problems, and then the period of reconstruction. But under Miers' care the University gathered strength, and his Vice-Chancellorship was marked by many new developments. Under his sympathetic guidance the University took its full share in civic activities.

He was particularly happy once again to be Professor of Crystallography. He lectured regularly with his old skill, and whenever he could snatch an hour from official duties he was in the laboratory helping the students with that encouragement and personal interest that so many of them remember with affection. He was too busy to do any research himself, but he took the keenest interest in the work that was in progress, very happy that it was in his own field, the effect of environment on crystal growth.

His term of office would normally have ended in 1923, but the Senate pressed him to remain until 1926. When he left he must have been touched by the warmth and spontaneity of the many tributes from the University and the City for all that he had done for them.

In 1926 he returned to London and bought a house in Hampstead, meaning to return to his scientific work. But it was not to be. First there were jobs to be rounded off, and then, ever willing and eager to help in any constructive work, he was drawn into fresh activities.

In 1926 he undertook a Report on our Museums and Art Galleries for the Carnegie United Kingdom Trustees with S. F. Markham as his Secretary. As a result Museums became his chief occupation and interest for the rest of his active life. He served on the Royal Commission on Museums and on the Standing Committee appointed to carry on its work. He was President of the Museums Association for six years and with Markham he made a survey of the Museums in the Empire for the Carnegie Corporation. Miers was convinced of the great part Museums could be made to play in the life of the people if they were recast and for ten years he was the acknowledged centre of progress in all museum work.

As the years wore on, even his tireless energy began to flag, and when his eyesight failed and made travelling difficult the Museum work was left more and more to Markham. But he was never idle, and in these last years his happiness was the collection of plants in the London district and the care of his collection of photographs of classical sculpture. He never lost his enthusiasms and his interest in the doings of friends and pupils.

Miers's life was spent in the service of others. He was a fine teacher of the most generous type, clear and encouraging, and making everyone feel that there was a place for him in the world. Modest, unselfish, loving his fellow men, he was perhaps a little too gentle at moments in debate when a firm lead was needed. But he was a great humanist, and at times like these when the ethical influence of science is often called in question, Miers is an example of what a man of science can do in applying scientific methods in administration, and to the wider problems of academic and national life.

HAROLD HARTLEY.

SIR ROBERT ROBERTSON.

1869—1949.

THE death of Sir Robert Robertson at the age of eighty removes from our midst a man of outstanding personality. Primarily an expert of world-wide repute in the field of explosives, he had a great variety of other interests, mainly scientific, but including also such subjects as classics and historical research. He was a Fellow of the Chemical Society for over forty years and was twice a Vice-President.

Robert Robertson was born on April 17th, 1869, in Cupar Fife, and was the son of J. A. Robertson, D.D.S. Both the father and the grandfather had somewhat of a scientific bent. Robert was the eldest of a family of four; of his three sisters one, Jess Isabel, married William Rintoul, a colleague of Robertson's in his explosive work. Robertson was married in 1903 to Kathleen Stannus, daughter of Hugh Stannus, F.R.I.B.A., lecturer in Applied Art at South Kensington and Manchester. She inherited his artistic ability and has produced many charming works of art. She died in 1938. Two children, a daughter and a son, survive Sir Robert.

1876—1885.

At the age of seven Robertson entered the Madras Academy, Cupar Fife. The curriculum did not include science, but a small laboratory was fitted up at home. He showed great industry at school and gained many prizes. On leaving, he was awarded the Balgonie Gold Medal. In the Senior Local Examination of St. Andrews University he was placed first in Scotland and won the University prize.

1885—1890.

Robertson matriculated at St. Andrews University in October 1885 for the M.A. degree. In the 1885—1886 Session there were sixty " bejant " students, as they are called at St. Andrews in their first academic year. Two of these, Robert Robertson and Alexander MacKenzie, attained the distinction of the Fellowship of the Royal Society.

The course extended over four Sessions. No chemistry classes were included; it was, however, possible to take extra classes if time permitted and Robertson found that he could attend classes in science in his third and fourth years, which would enable him to qualify for the B.Sc. degree. A fellow student, David Lawson, who had attended Purdie's chemistry lectures, spoke enthusiastically to Robertson about them and he decided to enter for a chemistry class. In the following year he took a more advanced class and came for the first time under the stimulating influence of Purdie. This made a tremendous impression on him and ultimately a life-long friendship sprang up. Robertson took the M.A. degree in 1889, and in 1890, after a further summer course, he took his B.Sc. degree.

His affection for his old University was almost a passion. In his later life he was a founder member of the St. Andrews Club, London (1904), and was for many years Chairman of Council. He was always interested in historical studies and made a study of the Avignon Popes of whom the last, Peter de Luna (Benedict XIII), founded St. Andrews University in 1411.

1890—1892.

On leaving College, Robertson entered the laboratory of the City Analyst in Glasgow and worked under Robert T. Thomson (who recently completed his fiftieth year as a Fellow of the Chemical Society). Through him, Robertson made the acquaintance of James Miln Thomson, manager of the Cordite Section of the Royal Gunpowder Factory at Waltham Abbey, and this was destined to lead his steps into the explosives world.

1892—1907.

In 1892 Robertson was appointed as a junior chemist (at twenty-seven shillings a week) under J. M. Thomson. Thomson encouraged his young assistants to undertake investigations, to give them a greater interest in their work. He set Robertson to work on the relationship between the nitrogen content of nitrocellulose and its solubility in ether–alcohol. Robertson also made experiments on the preparation and properties of ethylene dinitrate, and on the basis of this work he obtained the D.Sc. degree of St. Andrews University in 1897.

A further practice, instituted by J. M. Thomson, was that his young chemists should spend six months learning factory operations side by side with the workmen; thus Robertson acquired a first-hand knowledge of the processes.

In 1894 there was a serious explosion in the nitroglycerine plant. With great pluck Robertson and two others " drowned " the remaining nitroglycerine in water and thus probably averted a further explosion. For this act he was presented with a gold watch by the Government. He regarded this watch as one of his most valued possessions. He was placed in charge of the nitroglycerine manufacture until 1900. During this time he and William Rintoul worked out a process for recovering acetone vapour, which had previously been allowed to go to waste in the cordite driers. This depended on absorption by sodium hydrogen sulphite and was applied on a very large scale.

In 1900 Robertson was put in charge of the Main Laboratory. He had a certain amount of time available for research and made a study of the Will stability test for nitrocellulose in its application to the purification of gun-cotton by boiling with water. He found that the best method of purification was to boil the gun-cotton initially with weak acid to hydrolyse unstable impurities; the acids could then be removed by prolonged boiling with water. This valuable discovery was published in 1906 and has become the standard practice in gun-cotton manufacture. He followed up this work by modifying the Will test to adapt it to the measurement of the rate of decomposition of nitroglycerine.

In a further research with S. S. Napper the absorption spectrum of nitrogen dioxide was examined and it was found that nitrogen dioxide could be detected and measured in low concentrations in air. This was utilised to measure the gradual decomposition of nitrocellulose at medium temperatures.

At about this time some of the cordite came under suspicion of having inflamed spontaneously. The Will test threw no light on this, and Robertson introduced a new stability test, the " Silvered Vessel Test." The cordite was ground and heated at 80° in a vacuum-jacketed and silvered flask. The decomposition was detected, first by visible fumes of nitrogen dioxide and then by a rise of temperature. The cordite then in use contained 5% of mineral jelly, and he found that if the mineral jelly were omitted or replaced by saturated hydrocarbons the stability was greatly decreased. From this it was deduced that mineral jelly contained a small proportion of hydrocarbons which reacted with nitrogen dioxide. Since nitrogen dioxide acts as an auto-catalyst in the decomposition its removal is beneficial to the stability.

A field of work which was the subject of considerable investigation by Robertson was the calorimetry of the explosion of cordite. This was based on the work of Sir Andrew Noble. The cordite was placed in a thick-walled steel bomb which was immersed in a calorimeter. The effect of mineral jelly and of the proportion of nitroglycerine was measured.

1906—1907.

In the summer of 1906 spontaneous explosions took place in two magazines in India. This required urgent investigation, and Colonel Nathan and Dr. Robertson were sent out to India to undertake this. The Silvered Vessel Test proved its value in correlating the decline of stability with the temperature and time of storage, and it was possible to lay down a safety limit, below which the test should not be allowed to fall. An exhaustive report was made on the conditions of storage with recommendations for the preservation of cordite in hot climates, and this remained for many years a classic source of reference.

1907—1914.

On his return from India early in 1907, Robertson was invited to take up the position of Superintending Chemist at the Woolwich Research Department. This Department had been in existence for about six years. It arose out of an experimental establishment set up by the Explosives Committee. The Committee included a number of illustrious scientists, among whom were Lord Rayleigh, Sir William Crookes, and Sir Andrew Noble. They took a personal interest in the work, which was very encouraging to the small staff of about half-a-dozen chemists. The original terms of reference were to improve the detonation of lyddite and to overcome the defects of the cordite at that time in use. The work, however, widened rapidly; many explosives were synthesised and examined, notably trinitrophenylmethylnitramine, for which a manufacturing process was worked out. Important work on the stability of propellants was carried out and the study of trinitrotoluene was commenced. New and well-equipped laboratories were built and the work expanded greatly. Unfortunately, the scientific Explosives Committee gave place in 1906 to a Board in which science had relatively little representation and in 1907 a military " Superintendent of Research " was appointed. Such was the background of the Department at the time of Robertson's appointment on April 7th, 1907. His University course for the M.A. degree had left him relatively little time to obtain a comprehensive knowledge of chemistry, but he brought a valuable fund of technical experience and a useful knowledge of safety precautions to the Department. His organising ability had full scope; he was a good administrator and had abundant energy; painstaking, methodical, and cautious in arriving at decisions, but obstinate in adhering to them in the face of any opposition. He was domineering and issued his instructions in the form of abrupt and peremptory orders. The junior members of the staff were terrified of him.

He realised the necessity of amassing a systematic fund of information on all subjects connected with explosives. This aided in dealing with the increasing influx of Service problems.

In view of its importance the stability of cordite was one of the most prominent subjects of investigation. The deterioration of cordite starts from minute nuclei of impurities and spreads by autocatalysis. An exhaustive study of the nature of the harmful impurities was made by means of climatic storage trials. This led to a better control of the cordite stored in magazines and to the introduction of precautions in the manufacture.

Work on high explosives was also in progress. A comprehensive study of the properties of trinitrotoluene was made and the manufacture and purification of trinitrophenylmethylnitramine were perfected. Important researches on the initiation of detonation of high explosives and the sensitiveness of explosives to impact were carried out. Robertson showed a keen interest in the progress of the work; he also fulfilled a useful function in establishing contacts with other Service departments. The opportunities for publication were very restricted on account of its secrecy.

1914—1918.

With the outbreak of war in August 1914 the Research Department was put to a strenuous test. With a staff of nine chemists and subordinate staff it was required to cope with a host of problems in a minimum of time. The work was so wide-spread that it cannot be dealt with in any detail. A few outstanding examples may, however, be mentioned.

In October 1914 improvement in the supply of trinitrotoluene (T.N.T.) became extremely urgent. Robertson was asked whether his Department could make three tons a week of T.N.T. to relieve the position. He immediately gave orders that work should be put in hand at the highest pressure to establish the most efficient method of manufacture. The existing processes were slow and inefficient. They also required oleum, which was not available. Intensive laboratory work was put in hand and a number of radical improvements were worked out. After a short time the work had reached a stage at which an experimental plant could be designed. Robertson's technical knowledge then stood him in good stead; he made a personal search of the scrap heaps of Woolwich Arsenal to find the necessary equipment and a plant for three tons a week was soon erected. This gave successful results and it was kept in production for a considerable time. In the early stages the supply position was so crucial that each week's output was seized upon with avidity for shell-filling, etc. This process was taken as the basis of the design of the large-scale Government plant at Oldbury and later that at Queensferry.

Although this work led to the expansion of T.N.T. production to a very large scale, it was still limited by the available toluene and it soon became evident that a still larger supply of high explosive would be required. In order to eke out the T.N.T. the use of a mixture of T.N.T. and ammonium nitrate was investigated at the Research Department. Trinitrotoluene is in itself deficient in oxygen whilst ammonium nitrate has a slight excess. A balanced mixture would be obtained by adding about four parts of ammonium nitrate to one part of T.N.T. At that time it was necessary to add about 40% of T.N.T. to enable the mixture to be melted to a slurry and poured into shells, but this was remedied later and made it possible to use the mixture containing 80% of nitrate. The detonation of this mixture was a difficult matter and numerous other difficulties arose such as hygroscopicity, corrosion of metals owing to hydrolytic dissociation, formation of dangerous salts with copper, etc., decomposition of T.N.T. by traces of pyridine and thiocyanate, transitions of crystalline form at $-16°$, $32°$, $85°$, and $125°$. The ammonium nitrate had to be made from Chile saltpetre by double decomposition and was difficult to purify. These difficulties were overcome step by step and this " dilution " of the T.N.T. enabled the quantity of available high explosive to be increased enormously. The mixed explosive was named " Amatol." (I have refrained from mentioning names of the staff working under Robertson, but think that the name of E. R. Deacon, who has since passed away, should be put on record for his valuable work on amatol.)

Another difficulty was that amatol gave little or no smoke on detonation and this made it difficult to locate the burst of the shell. To remedy this, smoke mixtures were devised and incorporated into the shell filling.

Meanwhile serious difficulties arose in the production of cordite owing to shortage of acetone. It was necessary to devise a propellant of the same ballistic properties as cordite M.D. without using acetone; it was also necessary that manufacture should be capable of being carried out in the existing plant. This was met by the introduction of a new propellant, " Cordite R.D.B.", in which the solvent used was a mixture of ether and alcohol. This propellant was ultimately manufactured in enormous quantities in the largest propellant factory at Gretna.

As the war proceeded, the difficulty of obtaining chemists for research work and for manning the factories became more and more acute. Scientists had been sent to the Front regardless of their value in producing vital supplies of munitions. It is amusing to read in a leaflet issued by the Parliamentary Recruiting Committee the advice given for Enlistment in Special Corps : " Men specially enlisted (a) such as Navvies, Tunnellers and Chemists."

In 1917 Robertson went to France and interviewed many scientists. This ultimately led to the return of valuable scientific workers to this country.

At the end of the war in 1918 the staff of scientists numbered one hundred and ten. When the news of the Armistice arrived, Robertson and a group of the staff were engaged in a conclave. It was typical of Robertson that he solemnly proceeded with the discussion and for another hour the scientists had to possess themselves in patience and continue the discussion.

During the war Robertson worked untiringly. He made a point of visiting the laboratories as often as possible to get first-hand information on the progress of the work. I think it may be said that this formed the peak of his long and active career. He was in the prime of life and rendered truly great services.

It was during the first World War that he was elected a Fellow of the Royal Society (1917). In 1918 he was created a K.B.E. in recognition of his valuable work.

1919—1921.

Much research work remained to be done after the war, but the staff dwindled rapidly after the Armistice. Robertson's time was very much occupied in the question of reorganisation of the conditions of employment of scientists. He continued to be a member of the Ordnance Committee and several other Committees until he left the Department on March 6th, 1921.

1921—1936.

On the retirement of Sir James Dobbie, F.R.S., from the post of Government Chemist, Sir Robert was appointed to this position and took up his duties on March 7th, 1921. In the Government Laboratory, which was already very efficiently organised, he was free to devote himself to work which was congenial to him. He took part in many committees and found time for private research.

The post of Government Chemist carries with it other duties, as he is Chief Agricultural Analyst, Referee under the Food and Drugs Act, and Advisor to the Board of Customs and Excise. The magnitude of the work of the Government Laboratory can be judged to some extent from the impressive Annual Reports. It increased largely during Sir Robert's tenure, owing to legislation such as the Safeguarding of Industries Act, etc.

Apart from the routine analytical work, special investigations were carried out at the Laboratory to assist Departments of State, *e.g.*, the carriage of dangerous goods at sea, the elimination of sulphur dioxide and nitrous gases in the atmosphere, the effect of lead tetraethyl in petrol on health, the investigation of the mineral resources of the Dead Sea for the recovery of potassium chloride, bromine, etc. Sir Robert served on numerous Committees dealing with these and other subjects.

Research on Infra-red Absorption Spectra.—Robertson's great wish was to devote himself to research. He told me that he felt he must do research " to save his soul." The work on infra-red spectra dealt with the three hydrides NH_3, PH_3, AsH_3. Robertson's interest in the subject arose out of the explosive nature of arsine gas, and the original object was to determine whether its decomposition would be accelerated by exciting the molecule with one of its vibrational frequencies. He was fortunate in having the collaboration of J. J. Fox. who had considerable experience in spectroscopy. The work was described in a series of papers in the *Proceedings of the Royal Society* by Robertson, Fox, and Hiscocks.

Special precautions were necessary to overcome the effects of electro-magnetic disturbances and mechanical vibrations caused by heavy road traffic. A tetrahedral structure was deduced for each of the three molecules, though not of equal height. The moments of inertia were calculated. In addition to the rotation system shown by PH_3 and AsH_3, NH_3 was found to have a further system of rotation. Beer's law was found to hold accurately. At that time there were very few infra-red spectrometers in the whole world. There is no doubt that the work of Robertson and his colleagues greatly stimulated infra-red spectrometric work in this country and abroad.

Research on Diamonds.—The published work on the infra-red spectrum of diamonds showed some discrepancies and Robertson proceeded to make a study of diamonds from different sources. In the examination of the first six diamonds one behaved abnormally. The other five gave a strong absorption band at 8 μ. but the sixth gave no such band. Later, other examples of this abnormality were found. Differences were also found in the ultra-violet. Other physical properties were examined; some of these properties showed differences between the normal diamonds (Type I) and the abnormal (Type II). In all, six abnormal diamonds were found, out of a total of three hundred examined. The joint work (Robertson and Martin) was summarised in the Jubilee Lecture to the Society of Chemical Industry (*Chem. and Ind.*, 1944, 18) in which the significance of the physical properties was discussed and surmises were made as to the conditions of formation of the two types in Nature.

Robertson took some interest in the question of the artificial production of diamonds and examined the minute specimens left by J. B. Hannay to the British Museum in 1880. At least one of these proved to be of the abnormal type.

1936—1939.

Robertson retired from the Government Laboratory on April 16th, 1936. He continued, however, to serve on several Committees. In 1937 he resumed experimental work at the Davy Faraday Laboratory. He designed and made apparatus for the exploration of spectra into the deep infra-red, *i.e.*, from 100 μ. downwards. In the middle of 1939 the war clouds became ominous and at the age of 70 he offered his services to his old Research Department at Woolwich.

1939—1945.

At the outbreak of the war, the work of the Research Department was decentralised. Robertson was placed in charge of the section which was stationed at University College, Swansea. The work was already well organised and Sir Robert was thus free to spend a large proportion of his time on Committee work under the Scientific Advisory Council, where his wide knowledge of explosives was of great assistance. In 1939 he was appointed Chairman of the Committee on Higher Explosives. From 1940 to 1942 he was Chairman of the S.A.C. Committee on Chemistry of Explosives and Physics of Explosives. He served also on a number of other Committees. The attendance at the meetings in London involved a great deal of travelling and included some hundred night journeys, an effort which would have taxed the strength of many a younger man. He was awarded the Davy Medal of the Royal Society in 1944 in recognition of his valuable services to Science and the Nation.

1945—1949.

At the end of the war Robertson had attained the age of 76, but was still full of vigour. He resumed his work at the Davy Faraday Laboratory, perfecting the technique of infra-red work and experimenting on the synthesis of diamonds. He extended Hannay's work and endeavoured to obtain crystalline carbon from solutions of cyanides in molten silver and other metals.

He was a member of the Armaments Research Advisory Board until his death. He was Chairman of the Committee which dealt with the Armstrong Memorial Fund (1945—1948). He continued as a Censor of the Royal Institute of Chemistry until 1946.

In 1947 he took an active part in the Centenary Celebrations of the Chemical Society. He was Chairman of an Exhibition at the Science Museum illustrating the achievements of British chemists during the last one hundred years and brought together a remarkable collection of apparatus of historical interest.

In 1948 he was appointed Editor in Chief of a comprehensive work on " The Science of Explosives," but after putting much work into this he was ultimately compelled by failing health to relinquish the Editorship.

He was practically free from illness until the early part of 1948, when he had a bad heart and congestion of the lungs. His tough constitution pulled him through, but he was much weakened. In 1949 he had influenza and broncho-pneumonia and passed away at his home in London on April 28th, just eleven days after his 80th birthday. He might almost be said to have died in harness, and I am sure he would not have wished it otherwise.

Thus ended a long and strenuous career. It was probably fortunate for him that he had to forge his way by hard work in his early years. From the beginning he strove after success and achieved it in a high degree. His honours included a presentation gold watch from the Secretary of State for War in recognition of gallant behaviour after a serious explosion in 1894, the Fellowship of the Royal Society in 1917, the K.B.E. in 1918, LL.D. St. Andrews in 1923, the Silver Jubilee Medal in 1935, the Coronation Medal in 1937 and the Davy Medal of the Royal Society in 1944.

In all that he undertook he worked tirelessly and conscientiously; his tenacity of purpose carried him through many difficulties. He was supremely self-confident, frequently autocratic and domineering. His tough constitution enabled him to retain his vigour into old age and his studious disposition remained with him to the end. He strove after recognition, but he had also his sentimental side; he was greatly attached to his old University and to his chemistry professor, and had many other intimate friends for whom he had a real affection.

International Relationships in Chemistry.—An account of Robertson's activities would be incomplete without some reference to his efforts to further co-operation and friendly intercourse with scientists abroad. As President of the Chemical Section of the British Association at Toronto in 1924 he made many lasting friendships. Whilst on the American continent he travelled to Vancouver and back, and then to the United States, where he established profitable relations with our fellow-scientists. In 1927 he visited Paris as Royal Society representative at the Berthelot Celebrations and made a further visit in 1931. In 1930, and again in 1934, he visited Belgium and Northern France in connection with the problem of water-pollution. In 1934 he attended the International Congress of Chemistry at Madrid and in 1936 he visited Roumania, Istanbul, and Austria. In 1937 he went again to Paris for the Congress of Industrial Chemistry, and in 1938 he took part in the International Congress of Chemistry at Rome. He readily got on to a friendly footing with scientists abroad and in return he welcomed them on their visits to this country and showed them hospitality at his home. In so doing he rendered a real service to Science. With him national boundaries formed no barrier to the establishment of fraternal relations. During the war of 1939—1945 he was in very frequent contact with the Canadian and American representatives and did much to promote their co-operation.

In this connection the " Catalysts' Club " should be mentioned. It was established about thirty years ago, and one of its purposes was to entertain distinguished foreign visitors to this country having similar interests to those of the Club. Robertson took an active part in this and often presided at the meetings. The Club was well named and Robertson was distinctly a good catalyst. He was good company and, as one member put it, they liked his pawky humour.

Societies and Institutions.—Robertson's loyal devotion to the learned Societies was a feature which greatly impressed his colleagues and friends and he attended, and often presided at, a great number of scientific meetings.

Royal Society. Robertson was elected a Fellow in 1917. He served on a number of Committees, including the Committee on Applied Sciences (1919—1922) and the Committee for exhibit on Pure Sciences at the British Empire Exhibition (1922). He represented the Royal Society on the General Board and Executive Council of the N.P.L. (1925) and in the Berthelot Celebrations at Paris (1927). He was awarded the Davy Medal in 1944.

Chemical Society. He was elected as a Fellow in 1907 and was a Member of Council 1919—1922. He was a Vice-President in 1926—1929 and again in 1936—1939. In 1922 he represented the Chemical Society on the Conjoint Board of Scientific Societies. His activities in connection with the Centenary Celebrations are mentioned above.

Faraday Society. Elected 1920, he became a Member of Council in 1921 and was President in 1922—1924.

Royal Institution. Robertson was a devoted member of this Institution. He was elected in 1921, became Manager in 1924, Secretary 1926—1929 and Treasurer 1929—1946. During this time he acted as Vice-Chairman. When the renovation of the theatre and various building became urgent he took an active part in obtaining the necessary funds (about £100,000). During the Faraday Centenary Celebrations in 1931 he frequently presided at meetings.

British Association. Robertson was President of Section B (Chemistry) at the Toronto meeting of 1924.

Royal Institute of Chemistry. He became a Fellow in 1897, Member of Council 1915—1918 and 1921—1932, Vice-President 1918—1921.

Salters' Institute. Robertson was appointed Director in 1937 and continued to hold this post until shortly before his death.

London University. Member of Board of Studies for Chemistry and Chemical Industry 1921—1925 and 1944. Board of Advisors in Chemistry.

Ramsay Fellowships. Member of Advisory Committee 1921.

Ramsay Chemical Engineering Department. Member of Committee.

He was also a member of a number of other Scientific Societies and of the Royal Society Club and the Athenæum. His activities in connection with the St. Andrews University Club, London, have already been mentioned.

He maintained a close connection with the Scottish Universities through his position as Advisor in Physical Chemistry under the Carnegie Trust.

R. C. FARMER.

F. E. WHITMORE.

1923—1949.

FRANK EDWARD WHITMORE lost his life on July 25th, 1949, at the age of 26 in a climbing accident in Switzerland and his death came as a severe shock to his former teachers and to his colleagues and many friends in Birmingham.

Whitmore, one of three talented brothers, received his early education at Handsworth Grammar School from which he entered the Chemistry school of the University of Birmingham in 1942. Always a brilliant scholar, he duly graduated with first class Honours and was awarded a Teaching Scholarship in the Chemistry Department.

He engaged in research work under Dr. F. J. Llewellyn in the X-ray department, studying the single-crystal X-ray methods of determining the crystal structure of organic substances (explosives). With Llewellyn he published some of the work in the Journal (*J.*, 1947, 881).

On gaining his Ph.D. in 1946 he was appointed to an I.C.I. Fellowship which he held in the Department of Physics at Birmingham with the object of building up, with the unusual facilities available, a small group engaged in studying radiochemistry. In addition it was the object of his new group to look after general chemical problems of the Nuclear Physics laboratory and to provide a link with interested workers in the Chemistry Department. From the start, owing to his generous and helpful nature, this new venture was a marked success and in his researches Whitmore had already begun to make a name for himself. He was particularly interested in the chemical state of atoms newly formed by nuclear transformation, *e.g.*, in the cyclotron. He paid a good deal of attention to phosphorus 32, and showed that this element when made by the action of fast neutrons on the sulphur in sodium sulphide appears, when brought into aqueous solution, as a phosphate ion. Several papers on this work were in preparation for the press when he was killed.

His particular hobby was mountaineering and he was an enthusiastic, generous and able leader among Midland climbers. He had an unusual talent for amateur dramatics and in his undergraduate days was in great demand by the various University societies, particularly the University Chemical Society.

He was unmarried and leaves a widowed mother. Because of the long period of training necessary for such work, Whitmore's untimely end is a sad loss to radiochemistry and to Birmingham, and his place cannot easily be filled.

M. STACEY.