OBITUARY NOTICES.

RANDAL THOMAS MOWBRAY RAWDON BERKELEY, EARL OF BERKELEY.

1865—1942.

RANDAL THOMAS MOWBRAY RAWDON BERKELEY, eighth and last Earl of Berkeley, was head of a historic house which is one of the very few that can rightly claim a pre-Norman pedigree, tracing its descent from Eadnoth, a Saxon Thane, who was Staller to Edward the Confessor.

He was born in Brussels in 1865, and became Viscount Dursley in 1882 when his father succeeded his cousin in the Earldom. His mother was Cecile, daughter of Louis, Count de Melfort, whose ancestor John Drummond had followed James II into exile in France. He used to speak of his mother as having " a first-class reasoning mind " and this he certainly inherited from her. His parents lived abroad and he was educated at a lycée at Fontainebleau and later at Nice, until he came to England to be coached for the Navy, following the family tradition. He joined the *Britannia* in 1878, having passed in from Burney's Naval Academy at Gosport.

He quickly became an outstanding personality among his contemporaries. Above the average in physique, handsome, good at all games, he also took a high place in every examination, and was said to be " the best all-round man of our term." In those early days he was as wild as a hawk, ready to turn a back somersault off the mantelpiece for a bet and for any other physical feat of daring. His high spirits made naval discipline very irksome, and in spite of his promise as an officer he was often in trouble with their Lordships of the Admiralty. So it was no surprise to his friends when he left the Navy, although the immediate reason for this was his determination to do research.

He once told me that his interest in science and mathematics was first awakened during his school holidays before he joined the *Britannia* when he was taken to see Bidder, the " calculating phenomenon." Bidder was then an old man, but Berkeley was thrilled by his lightning calculations of engineering quantities, such as the number of bricks needed to build a complicated skew bridge over a river, and the deep impression made on the boy's mind was to bear abundant fruit. Years later his interest was stimulated again by a chaplain in one of the ships he served in who lent him books on chemistry which so inspired him that he decided to leave the Service and devote himself to science.

He resigned his commission in 1887 and in the same year he married the widow of Arthur Jackson. He then started to do chemistry at South Kensington under T. E. Thorpe, at the same time going to lectures in other subjects, including geology, to widen his knowledge. He wanted to choose his own line of research and this was not easy for a beginner, until a lecture on petrography by Judd aroused his interest in crystals, with the result that he began to study the relationship of crystal structure and chemical composition. Then a serious illness (double pneumonia) put an end to his work at South Kensington, and he was told that he could not winter again in England. However, he made a good recovery after a winter at St. Moritz and was able to take up research again on condition that he left London. So in 1893 he bought a house at Foxcombe on Boar's Hill just outside Oxford, and began his first experimental research in the Christ Church laboratory on an improved method of determining the density of crystals.

The work on crystal structure was abandoned when the investigations of Tutton, Pope and Barlow came on the horizon, but Berkeley always kept his interest in the phenomenon of crystallisation. Next came a research with Ernald Hartley in 1897 in the Balliol Laboratory (in the cellar on staircase XVI) on the electrolysis of glass, following on some work by Roberts Austen, and this turned his attention to semi-permeable membranes.

In 1898 he built a small laboratory at Foxcombe and began to plan a comprehensive attack on the application of van der Waals' equation to solutions, involving the determination of osmotic pressures. His first work there on the densities of saturated solutions was published in the *Philosophical Transactions* in 1904. The measurements were made with skill and accuracy and showed that he was gifted with an unusually fine sense of technique.

In 1902 the osmotic pressure work began in earnest when he was joined by Ernald Hartley, who was his collaborator until 1916 in this field. Berkeley was particularly fortunate in the choice of the first member of the Foxcombe team, as Hartley shared his own interest in accurate technique (his early work on mineral analysis had shown his manipulative skill) and his wide knowledge of chemical substances and his sagacity made him an invaluable partner in the osmotic pressure work.

Comparatively few osmotic pressures can be measured directly, and for such a comprehensive survey as Berkeley originally planned indirect methods must be used; hence his first goal was to check the accuracy of the indirect methods by direct measurement in some specified cases. This led him to a long series of researches pursued with great imagination and tenacity throughout his life, which remain to-day as the classical investigation in this field.

The new laboratory at Foxcombe was admirably planned and built for research in physical chemistry, and work started there in 1902 on the determination of the osmotic pressure of cane sugar solutions. The measurement of pressures running up to 150 atmospheres involved engineering design in which Berkeley showed real genius and he was well backed up by his mechanic Treeby, who carried out his ideas with great skill. The semi-permeable membranes of copper ferrocyanide were formed on the outside of cylinders of Berlin porcelain, which were carried in a gun-metal vessel to which the necessary hydrostatic pressure could be applied to prevent the passage of water into the solution through the membrane. After many trials two almost perfect membranes were produced which served for all the work.

Simultaneously with these direct measurements the osmotic pressures were determined by the vapour pressure method due to Arrhenius. In this air is drawn first through the solutions and then through the pure solvent, when the lowering of the vapour pressure can be calculated from the losses in weight. It was soon found that the bubbling method was inaccurate, as the bubbles of air increased in size with the change in hydrostatic pressure and were never saturated, so a chain of vessels rocked in a thermostat was used in which the air passed over the surface of solution and solvent, thus practically eliminating the change in pressure across the apparatus. Even with this improvement the osmotic pressures calculated by the Arrhenius formula differed considerably from those determined directly. This turned Berkeley's attention to the thermodynamic cycle by which the Arrhenius equation was obtained, and he devised a more exact form of the expression, taking into account the variations of density with height of the columns, which brought the indirect values to within a few units per cent. of those directly measured. This was the start of his interest in thermodynamics, in which he became a great adept, particularly in the field of cyclic processes applied to solutions, an interest which continued unabated until his last paper of 1935. He was one of the first to insist on the importance of chemical thermodynamics in this country.

In 1907 Berkeley invited Charles Burton of the Cambridge Scientific Instrument Company to come to Foxcombe to help in the mathematical and instrumental sides of the work. Burton had already helped in the design of the apparatus made at Cambridge and had in fact suggested the general design of the osmotic pressure apparatus. He was in many ways a great addition to the team.

After Berkeley and Hartley had pointed out the main error in the Arrhenius equation, A. W. Porter had re-examined the thermodynamic cycle on which it was based and had derived an exact relationship between the osmotic pressure and vapour pressure lowering. The application of this involved the determination of the compressibility of the solutions and this was Burton's first work at Foxcombe. Berkeley had made a long search for ionised substances towards which the copper ferrocyanide membranes were semi-permeable in order to relate their osmotic pressure and dissociation, and in 1908 two papers appeared in the *Philosophical Transactions* on the osmotic pressure of calcium ferrocyanide which fulfilled this condition. In these the Porter equation, slightly modified, was applied for the first time and the direct and indirect determinations agreed to within 0·5%. Immense pains had been taken to improve the vapour pressure apparatus and eliminate every source of error.

The ionisation in such strong solutions was too complex a phenomenon to make the conductivity measurements of much significance, and the main result of this work was definitely to establish the validity of the exact equation for the indirect measurement of osmotic pressures, the primary goal at which Berkeley was aiming. However, the matter was not allowed to rest here and experiments were continued over the next eight years with new experimental refinements and a continuous search for sources of error in order to develop the most accurate and elegant methods of measuring osmotic pressures.

With the advent of Burton in 1907 the theoretical field was extended and a joint paper on the " Osmotic theory of solutions " two years later broke fresh ground in establishing the relationship between the two osmotic pressures in any liquid system of two components (or rather between their differential coefficients, a distinction to which Burton attached importance). Consideration of the differences in concentration due to gravitational attraction in the long columns of solution assumed to exist in the thermodynamic cycles applied to osmotic pressure led to a calculation of the changes in concentration produced by centrifugal force and an attempt to verify the result by experiment. I fancy that Berkeley always preferred the use of thermodynamic cycles to other methods because he felt that they kept him in close touch with physical realities and thereby enabled him to interpret the results and examine critically the assumptions on which they were based.

Van Calcar and de Bruyn had examined the changes in concentration produced by whirling a solution of cane sugar for four hours and taking samples at different points while the solution was in motion. Their results were irregular and far greater than theory predicted. Berkeley and Burton rotated narrow glass tubes containing a solution of cæsium chloride in a massive flat circular box of gun-metal at a speed of 57 revolutions per second for 243 hours and showed that the changes in concentration in the bottom, middle and top layers were of the same order as are required by theory. This was the beginning of a long and elaborate series of experiments on rates of diffusion and the stratification of centrifuged solutions in which Berkeley's ingenuity in devising new methods had full scope. Both investigations involved great experimental difficulties if they were to yield accurate results. The temperature of elaborate apparatus had to be maintained at a high degree of constancy for long periods, sometimes many days, to avoid convection currents. Samples had to be isolated at different points without risk of mixing, or the concentrations measured *in situ* by interferometer methods. Michelson, Fabry and Perrot, and Rayleigh instruments were all pressed into service for this purpose, but unfortunately the work was still in the experimental stage in 1914 and was never completed.

As the scope of the attack on the properties of solutions widened, the Foxcombe team had to be increased to meet the growing programme of research. M. P. Applebey (now Research Manager at Billingham) came to work on the boiling points of water and saturated solutions and on diffusion, J. W. Stephenson on the electrical conductivity of solutions, B. H. Wilsdon (now Director of Research at the Wool Industries Research Laboratory) on diffusion and osmotic pressure in non-aqueous solvents, and D. E. Thomas on the partial pressures of the vapours of miscible liquids.

Meanwhile Berkeley's own mind was constantly at work trying to deduce from his results an equation of state for solutions, and to interpret the physical significance of osmotic phenomena. His paper in 1912 on "Solubility and supersolubility from the osmotic standpoint" shows the trend of his thoughts at this time. Starting with an analysis of the forms of the two osmotic pressure curves of two partially miscible liquids, he showed that at the concentrations where separation into layers occurs the form of the curves indicates a state of instability similar to that shown by the van der Waals curves where the separation of liquid from vapour occurs. He discusses in the light of this the conditions which would favour the separation of the new phase and the existence of a limit to the possible degree of supersaturation. He showed experimentally, following on the work of the American investigator Young, that the concentration at which crystallisation occurred in a supersaturated solution depended on the degree of mechanical shock to which it was subjected. This he explained as due to the setting up of compression-rarefaction waves in the solution, which brought it locally into the condition corresponding to a point of instability in his theoretical osmotic pressure curves.

In 1912 work at Foxcombe was in full swing and when Theodore Richards was in England to deliver the Faraday lecture I took him to spend the day with Berkeley. Richards was full of admiration for the laboratory and the two men were in immediate sympathy with one another, for they shared the same passion for accurate technique and the relentless pursuit of hidden errors. Few investigators fulfilled as well as Berkeley Richards' creed—

"First and foremost I should emphasise the overwhelming importance of perfect sincerity and truth; one must purge oneself of the very human tendency to look only at the favourable aspects of his work, and be ever on the look-out for self-deception (which may be quite unintentional). Each step should be questioned, and each possibility of improvement realised. And then, patience, patience! Only by unremitting, persistent labour can a lasting outcome be reached."

Those were the great days of the Foxcombe Laboratory, alas to end so abruptly with the war of 1914. Berkeley had chosen a fine well-balanced team and how good a leader he was can be seen from Applebey's sketch of the laboratory in the year he was working there—

"I went to work with Lord Berkeley," he says, "in 1910, when as you say he was in his most productive period. The great papers on the determination of osmotic pressure and vapour pressure had recently appeared, in which Berkeley had shown himself to be an experimenter of skill and imagination. The osmotic pressure work was, if not the first, surely the most notably successful of early applications of first-class engineering to the solution of experimental problems. The resource with which innumerable difficulties were overcome and the resolute rejection of all data on which the slightest suspicion could be thrown make this early work a model and an inspiration.

"When I got to Foxcombe, Berkeley's team already included Ernald Hartley, his invaluable and entirely reliable collaborator in the osmotic pressure work, and Charles Burton, a mathematical physicist of great and overflowing genius. The place was alight with enthusiasm and Berkeley's mind was stretching out in countless directions all radiating from his achievement in osmotic pressure. From cane sugar, one of the few solutes which was satisfactorily held by the copper ferrocyanide membrane, he turned to other sugars and glucosides, to the ferrocyanides of calcium and strontium and to the tetramethyl ester of ferrocyanic acid, itself only obtained by Hartley's painstaking and beautiful work, which incidentally revealed a new series of co-ordination compounds of great interest. All these were examined by the osmotic and vapour pressure methods. At the same time the investigation of osmotic properties by the boiling point method was ingeniously attacked, with particular attention to saturated solutions of salts. Berkeley's mind was much occupied from the outset I think with the problems of solubility and supersaturation. In his early papers he made too much effort to fit osmotic pressures to the model of the gas laws. He felt that osmotic pressure should obey some law of a modified van der Waals type, the discovery of which would give him the conditions of separation of the solute, just as van der Waals gives the conditions of separation of a condensate from a vapour. We shall all remember the patience and persistence with which he spent hours and days grinding out on the calculating machine trials of one empirical formula after another in the pursuit of this ignis fatuus. Nevertheless there was eventually notable fruit from this effort; thermodynamics was in his blood and was stimulated greatly by Burton, and the thermodynamic study of the solubility problem led him a few years later to what seems to me his most daring and greatest intellectual achievement, the great paper on "Solubility and supersolubility from the osmotic standpoint."

"It was impossible to be in Lord Berkeley's laboratory without being conscious of his intellectual powers. He was perhaps the better for not having passed through the common intellectual mill. He lacked some knowledge he might have acquired, but he was left with a very free mind. His speculations were ingenious, his imagination active and he never lost sight of the necessity for keeping his feet on the solid ground of experimental facts. Hating public discussion, he loved argument in his own circle. My most grateful recollection of him is the stimulation of the daily sessions at the blackboard when he would put up his ideas to be shot at. His ready ear for criticism, his anxiety to give credit to a younger colleague and his leaping mind made all this a stimulating period of my life for which I can never be too grateful."

During these years Berkeley's only other interest than science was golf, which he began to play under doctor's orders. Here again his instinctive grasp of scientific method and his application of it to anything he took up soon had its effect. (He once spent a morning in the laboratory graduating a glass vessel to be used in his kitchen to standardise the making of mayonnaise !) He read most of the standard books on golf, he visited the famous courses and played with the best professionals, but their empirical methods did not satisfy him. So he set himself the problem of working out the dynamics of each type of shot and evolved his own methods. He laid out a nine-hole course at Foxcombe on novel principles to suit his own style and on this he was soon almost unbeatable. He would leave the laboratory in the afternoon, his caddie carrying a sack of golf balls and a mysterious bundle of canes. These were used for marking out new bunkers which sprang up most unexpectedly where his own practice shots never landed the ball, but sagaciously placed for the discomfiture of his visiting opponents. The greens were similar pitfalls for the unwary, being clothed with different kinds of grass and tended individually with special routine. The first, a peculiarly impossible hole, was known as Pa's Perk. Within a few years he made himself a scratch player and he entered twice for the Amateur Championship without, however, getting very far.

Lady Berkeley had died in 1898 and at Foxcombe he lived an almost monastic life, absorbed in research and golf. But visitors in those years will remember gratefully his step-daughter, Miss Sybil Jackson, who was his hostess, and particularly her most beautiful voice and rare gift for music.

After August, 1914, the team gradually dispersed to war work of various kinds, Burton to lose his life owing to an accident when engaged in war research, and Berkeley was left to gather up the threads of the osmotic pressure work that had been pursued unremittingly until then. One paper gave the final results of all the determinations made with Hartley by the direct method on both ionised and un-ionised solutions, and a second describes in detail the final experimental refinements of the vapour pressure method and the more exact thermodynamic equation used to calculate the osmotic pressures. The compressibilities had been redetermined by Burton by a more exact method. G. W. Walker, the Cambridge mathematician who came to Foxcombe in 1916, had made a fresh analysis of the Burton correction for the slight expansion of the air in passing from the solution vessel to the solvent vessel in the vapour pressure method. Every other source of error had been reexamined with truly meticulous care and any remaining inexactitudes in the method of calculation had been eliminated. The final tables of results showing the very close agreement of the values from the direct and the indirect determinations of osmotic pressure were a triumphal ending to Berkeley's work in this most exacting field and established finally the validity of his vapour pressure method. For cane sugar, for example, the values were—

Osmotic pressure of cane sugar solutions at 0°.

Concn. in g. per l.	56·50	81·20	112·00	141·00	183·00	217·50	243·00
O.P. measured directly	43·84	67·68	100·43	134·71	—	—	—
O.P. calc. from vapour pressure	43·91	67·43	100·53	134·86	186·86	230·70	264·46

Berkeley, however, was never satisfied and always striving after greater perfection, and until 1918 G. W. Walker continued Burton's theoretical investigation of the possible sources of error in the V.P. work, while Stenhouse took Hartley's place in the laboratory to investigate further refinements on the practical side. But whatever plans he may have had for resuming work at Foxcombe at the end of the war soon vanished on the death of his kinsman, Lord FitzHardinge, late in 1916, when he succeeded to Berkeley Castle and the Berkeley estates.

The Castle had been neglected for many years, it was in a sad state of repair, many of the walls being covered with ivy which had wrought havoc with the masonry. Parts of it had fallen into ruin even before Cromwell " slighted " it in 1639. Berkeley had always had a passion for building and his imagination was fired by the idea of restoring the Castle as far as possible to its original plan, and making it at the same time a beautiful home. For fourteen years it was his main occupation, and Berkeley Castle stands today as a " memorial to his taste, his sense of perfection and to that capacity for taking pains that is akin to genius, if it is not genius itself."

Among the ancestral responsibilities to which he succeeded in 1916 was the Mastership of the Berkeley Hounds. To the surprise of many he began hunting from the start, although he had practically no knowledge of horsemanship or of horses and was over fifty. However, with his usual determination he was soon able to acquit himself well and was generally up with hounds. This endeared him to his field, especially the farmers, who admired his pluck and dash.

Since leaving the Navy his life had been spent mainly at Foxcombe and Berkeley, but in 1924, after his marriage to Mrs. Lloyd, a daughter of the late John Lowell of Boston, U.S.A., much of his time was spent out of England. After he had given up the Mastership and the Foxcombe Laboratory was closed (1928) each winter was spent in Lady Berkeley's house at Santa Barbara in California, where he was immensely popular with a large circle of American friends, who admired his complete simplicity. He had taken up golf again and in his reach-me-down alpaca coat and old white canvas shoes he would beat the heads off smart young men who were many years his junior.

In the spring they always went to Italy, where Lady Berkeley was painting frescoes in a chapel at Assisi. They had taken a villa on a hilltop overlooking Rome, with a beautiful garden from which there was a glimpse of the dome of St. Peter's framed in an opening between the trees. Berkeley, as usual, was busy with additions and improvements, including the sound-proofing of the dining-room, previously notorious for its echoes.

June found them back at Berkeley for the summer to see their English friends, and many an hour was spent in his study discussing O.P. and V.P. and their future possibilities.

He started to play golf again in 1925 and made a short course at Berkeley. He also began to write a book on his own methods, which was published ten years later under the title of *Sound Golf by Applying Principles to Practice.* It contained the results of years of study of the easiest methods of playing shots. Berkeley divided golfers into " tigers," " goats " (" their heads much lighter than their nimbler heels ") and " rabbits," counting himself among the " goats " though he once had been a " tiger." His book was written for the " goat," the average golfer, to show him what he considered the simplest ways of playing different shots, which he had evolved by studying each of them as a problem in dynamics. I know of no other book which sets out in simple words the scientific analysis of the factors that affect the accuracy of each stroke. The " rabbits " who were his guests will recall how he tried to teach them his favourite shots like the " pinch " and the " poached egg."

However, in spite of all the new interests and excitements in his life, Berkeley never lost his affection for research and the problems of osmotic pressure were always in his mind. He was still anxious to perfect further the V.P. technique, so that it would be applicable to other solvents than water and to remove the last uncertainties in the calculation of osmotic pressures from the results. From 1916 until 1918 when he went to live at the Castle he continued to take an active part in the laboratory. The vapour pressure measurements had become more elaborate and exacting, and examining the effect of varying the experimental technique was a slow business, but Berkeley's patience was untiring. He worked harder than any one and was incessantly planning new refinements and improvements of technique. He worked quickly with deft manipulation and was never happier than when setting up new apparatus. Once when Stenhouse was lamenting that an analysis had taken more time than he had expected, Berkeley said characteristically, " Don't worry about that. The only thing that matters is accuracy. In our work we must behave as if we expected to live for ever."

Berkeley's main experimental interest in these years was to discover the deviations of the vapours of such common solvents as water, methyl and ethyl alcohols, and benzene from the gas laws so that the appropriate corrections might be applied in the O.P. calculations. This problem he attacked by measuring the relative losses from different liquids when the same air current passed over them, also the corresponding losses from the same liquid at different temperatures. After 1918 Stenhouse continued the work single-handed, but Berkeley followed it with the keenest interest, making frequent visits to Foxcombe when he was in England, and writing often several times a week when he was abroad. The work went on until the end of 1928 and I well remember the sad moment when the shafting stopped for the last time after supplying the motive power to so many brilliant experiments for nearly thirty years. The results, published in 1930 in a paper on " The density of the vapours in equilibrium with water, ethyl alcohol, methyl alcohol, and benzene," showed that there were deviations from the gas laws which were, however, difficult to interpret. Incidentally the experiments threw a good deal of light on the difficulties that would be encountered in applying the method he had elaborated so successfully for water to other solvents.

But though this was the end of his experimental work, which Berkeley never ceased to regret—he used to say that his happiest days were in the laboratory—his interest in osmotic pressure and osmotic phenomena continued to the end of his life. His calculating machine was never idle for long and letters and manuscripts used to arrive from California and Rome, with recalculations of his results, more exact thermodynamic equations, or suggesting new lines of attack. When he was in England there were long talks in his study at the Castle with the late Oliver Gatty, whose skilful help in the intricacies of thermodynamics Berkeley greatly valued.

His last two papers were published in the *Philosophical Magazine* in 1933 and 1935. The first was on an ingenious empirical equation by means of which the osmotic pressures of un-ionised aqueous solutions can be calculated from certain physical constants if one osmotic pressure is known. As usual there is a discussion of the physical significance of the equation, to which Berkeley's thoughts always turned. In trying to apply it to mixtures of alcohol and water he ran into difficulties. This turned his mind back to the Berkeley–Burton modification of the Porter equation for the osmotic pressures of solutions with two volatile constituents, and the object of his last paper on the general solution of this problem was to find the simplest means of applying this in practice. He once said that he was really more interested in mathematics than chemistry and his skilful treatment of some complex thermodynamic cycles showed that he had lost none of his old cunning in his seventieth year.

He died peacefully in his sleep on January 15th, 1942, and as he had no children by either marriage the romantic earldom of Berkeley ended with him.

HAROLD HARTLEY.

ALFRED ARCHIBALD BOON.

1866—1943.

THE death occurred in Edinburgh on April 1st, 1943, of Alfred Archibald Boon, D.Sc., B.A., F.I.C., F.R.S.E., Emeritus Professor of Chemistry in the Heriot-Watt College. He was unmarried and had been in failing health for some years.

Born in India, where his father was in the Indian Medical Service, Boon graduated B.A. at Madras University. He than came to Edinburgh University to study Chemistry under Crum Brown and Natural Philosophy under Tait, whose lectures appealed to him very strongly. He graduated B.Sc. in 1898, was awarded a Research Fellowship, and took the D.Sc. degree in 1905. His researches were in the field of Organic Chemistry; he was always keenly interested in the medical and pharmacological aspects of his subject.

For some years Boon was on the staff of one of the Training Colleges in Edinburgh and was also a part-time member of the Chemistry staff of the Heriot-Watt College. On two occasions, he conducted courses for teachers in Dublin on the invitation of the Board of Agriculture and Technical Instruction for Ireland. He soon became a full-time member of the staff of the Heriot-Watt College as lecturer in Organic Chemistry, Assistant Professor and, after the death of Professor John Gibson, he was appointed Professor of Chemistry in 1919, a post which he held until his retirement in 1931, with the title of Emeritus Professor.

Boon's research work was published in the *Journal* of this Society and in the *Journal* of the Pharmaceutical Society. He was interested in oxonium salts, particularly in the diarylidene-dimethylpyrones, which he found to be coloured basic compounds giving intensely coloured salts, and published several papers on this subject. Other investigations dealt with the reactions of pinacolone with ketols, such as benzoin, and with aldehydes. Amongst other topics which engaged his attention were aminoarsonic acids of the naphthalene series and the reaction between *mm'*-dinitrobenzil and diamines. In the latter case, he found that the reaction with benzidine or *o*-tolidine led to the formation not of a quinoxaline but of an additive compound between the two reactants. Based upon this fact, he devised a method, using benzidine, for the isolation of *mm'*-dinitrobenzil from the mixture resulting from the nitration of benzil. The writer can testify as to the scrupulous care taken by Boon in these investigations; he would not publish until he was completely satisfied with the accuracy of his results.

Boon was a very able teacher and took great care in the supervision and administration of his Department, which developed greatly under his direction, among the developments being courses in paper-making, brewing, and pharmacy. The interests of his Department and of his students came first, as many of his former students could testify. He never seemed to forget a student even after many years, and was always interested in their subsequent careers. The heavy administrative and teaching work he had to bear gave him little opportunities for research; in all his teaching he always stressed the great importance of fundamental principles.

During the last war, he undertook investigations for the Services, particularly for the Admiralty, such as the systematic examination of oils collected from the surface of the North Sea whenever a German submarine was destroyed, the first of these being at Fidra in the Firth of Forth. He also took part in work for the Ministry of Munitions.

On two occasions, Boon served on the Council of the Institute of Chemistry; he was for many years a Member of the Board of Examiners in Scotland of the Pharmaceutical Society of Great Britain, and served on several Committees dealing with the training of pharmacists, a question in which he was deeply interested.

A man of deep religious convictions, Boon was a hater of injustice, was very conscientious, fair minded, and helpful to any who sought his help or advice—advice given after careful consideration. A cricketer and a swimmer in his younger days, he took up golf in later years and enjoyed his holiday in North Berwick; he became an able player, as many of his friends found. To those who knew him he was a true friend.

F. J. WILSON.

SAMUEL FELIX DUFTON.

1867—1943.

SAMUEL FELIX DUFTON was born at Leeds on February 14th, 1867, the son of John Dufton of Bradford. He and his brother Arthur were educated at Bradford Grammar School, noted for the number of its scholars who attained distinction in after life. Of Dufton's contemporaries, one may mention Sir A. Colefax, K.C., Sir F. Dyson (Astronomer Royal), J. S. Fairbairn (gynæcologist), J. A. Gardner, W. W. Marriner (ship-builder), R. S. Morrell, G. A. Schott (mathematical physicist), and Cutcliff Hyne (originator of Captain Kettle), who is known to an even wider public.

Mr. Gardner has helped me with the foregoing list and given me a very interesting account of the Grammar School in the '80s. If space allowed, I should like to reproduce most of his letter but must limit myself to one or two quotations which give some idea of Dufton's youthful environment.

" We had the advantage of a really great Headmaster—the Rev. W. H. Keeling (Wadham, Oxford), who guided the school with great ability and acumen in the days when problems of education were urgent in the West Riding." Science was in charge of R. E. Steel (Magdalen, Oxford), who " kept his eye on individual boys, whom he used to persuade to come into his Science VI—either directly or through their parents. In this way he got together a more or less picked class—much to the indignation of masters of other subjects." Steel was evidently a good friend as well as a good teacher; Mr. Gardner speaks of him very warmly.

Dufton went to Trinity College, Cambridge, in 1885 as an Entrance Exhibitioner; he became a Sizar in 1886, a Scholar in 1888 and a Fellow in 1892. He took the Natural Sciences Tripos, Part I, in 1887 (1st Class) and Part II in 1889 (1st Class, Chemistry). Meanwhile he had taken the examinations for a London degree, gaining First Class Honours at the Inter. Sci. and Final B.Sc. Examinations. He headed the list in

Chemistry, gaining the Exhibition, and was second in Physics, being awarded the Neil Arnott medal. He took the D.Sc. degree in 1892.

Dufton was an active member of the Cambridge University Natural Science Club, to which he contributed six papers. Of these, the titles of two reflect his North Country upbringing; they are the " Metallurgy of Iron and Steel " and " Dyes and Dyeing." It was at this time that the present writer made Dufton's acquaintance and this ripened into friendship when we both acted as Junior Demonstrators (1891—1892) in the University Chemical Laboratory, especially as we had neighbouring benches in the Research Laboratory at which we spent the greater part of our time.

Dufton's first research work was carried out with S. Ruhemann, to whom many Cambridge men were deeply indebted not only for his careful training but also for his infectious enthusiasm. This work concerned itself with muconic acid and its derivatives (J., 1891, **59**, 26,760), thus mucic acid was converted into dichloromuconyl chloride by the action of phosphorus pentachloride in presence of the oxychloride.

In a short time, Dufton launched out on independent work. Having improved the methods for nitrating quinoline and perfected the separation of the 5- and the 8-nitroquinoline, he was in the position to prepare the corresponding amino- and hydrazino-compounds in reasonable quantity (J., 1891, **59**, 756; 1892, **61**, 782). The hydrazones of pyruvic acid only needed boiling for an hour with hydrochloric acid to undergo indole condensation giving excellent yields.

On leaving Cambridge, Dufton went back to his old school as Science Master. Writing in " The Bradfordian," Mr. H. E. Boothroyd says :

"' Never shall we forget that tall, handsome, smiling young man, radiating happiness wherever he went, then, as all through his life.

" Even as schoolboys we thought his second name, Felix, singularly appropriate."

Dufton was not very long at Bradford, being appointed one of the first lot of Inspectors of Secondary Schools (Acland's Twelve Apostles). Research work had to be put aside and it was years before Dufton's name again appeared in scientific literature. Meanwhile he led a happy and useful life, becoming eventually Staff H.M.I. for Science in Secondary Schools. Mr. Boothroyd, a colleague in the Board of Education, bears witness in the notice already quoted, to Dufton's sympathetic help to secondary schoolmasters.

But Dufton never developed into the type of official who loses touch with the pursuit of science for its own sake and its bearing on everyday life. Chemists should be thankful for this; it was during the last war that he invented the distilling column which bears his name; an account was published shortly afterwards (*J. Soc. Chem. Ind.*, 1919, **38**, 45T; see also A. F. Dufton, J., 1921, **119**, 1988; 1922, **121**, 306). That one could get better results with a piece of apparatus one could make for oneself at small cost than with the fragile and expensive still-heads then in use, seemed too good to be true. But it was so.

Another of Dufton's activities was propaganda on behalf of economy of fuel. He frequently gave lectures on the subject; the present writer has recently read an address on " A Smokeless Leeds " given to the Leeds Luncheon Club (*Yorkshire Post*, November 20th, 1916) in which he advocates the increased use of gas, the cleaning of coal before coking, and complete abolition of bee-hive coke-ovens.

Dufton had been in failing health for some time; the end came suddenly; he was taken ill in his garden on June 24th, 1943, and died shortly afterwards.

He married Ellen Thornton, daughter of John Thornton of Leeds, in 1893. She survives him, with his daughter Lady Moran, and his son, Lieut.-Col. F. G. Dufton, Royal Engineers.

Our sympathy goes out to his widow and family, and the present writer regrets that meetings with Dufton were so infrequent since his Cambridge days.

J. T. HEWITT.

HAROLD GORDON RULE.

1887—1943.

H. GORDON RULE, D.Sc. (Edin.), Ph.D. (Munich), B.Sc. (London), Reader in Chemistry, University of Edinburgh, died on March 15th, 1943, after a long illness. He was one of three sons of the late Captain Thomas Rule, R.N. From Hillhead High School, Glasgow, Rule went to the Birkbeck College, London, and in 1909 graduated with first-class honours in chemistry. After a further year there, in which he engaged in research with Professor Alex. McKenzie, he proceeded to Baeyer's laboratory in Munich and worked under Professor Otto Dimroth on the problem of intramolecular transformations. Rule returned in 1912 to the Birkbeck College as an assistant and a year later was invited by Professor Sir James Walker to come to the University of Edinburgh, in which for thirty years he gave devoted service.

Rule's health did not permit his serving in the Navy as his father had done; but during the years of the Great War, in addition to arduous teaching duties and research for his D.Sc. thesis, he worked on problems of " national importance," such as the insulation of field telephone wire and the preparation of poison gases. The subject matter of his D.Sc. thesis appeared under the title " Amidine Salts and the Constitution of the so-called Iminohydrins " (J., 1918, **113**, 3). The combined application of physical and synthetic methods here described is typical of Rule's subsequent work.

The opening of the spacious new Chemistry Department at King's Buildings shortly after the end of the

War offered Rule great opportunities as head of the Organic Chemistry Department, in the planning of which he gave Sir James Walker invaluable help. Moreover on the institution of the Ph.D. degree in the Scottish Universities a steady stream of post-graduate students came to work under the active supervision and inspiring guidance of Rule. Within the next twenty years some sixty contributions (mostly to the Society) testified to his industry and that of his students. Mention should be made of his paper entitled " Optical Activity and the Polarity of Groups attached to the Asymmetric Atom " (J., 1924, **125**, 1121), which introduced a series of some thirty papers dealing with the factors governing the magnitude of optical rotatory power in which Rule showed conclusively the prime importance of the nature of the polar groups in asymmetric molecules and also in the solvents employed. Much of Rule's work is summarised in a paper which, at the request of the late Professor Lowry, he read at the Faraday Society General Discussion upon Optical Activity (see *Trans. Faraday Soc.*, 1930, **26**, 321).

In later years Rule turned to the study of benzanthrone and allied compounds and, successfully overcoming formidable experimental difficulties, obtained many interesting results. In one of his last papers, however, he returned to the subject of optical activity and with G. M. Henderson published an account of the first complete resolution of a racemic compound by chromatographic adsorption (J., 1939, 1568).

All Rule's work was characterised by thoroughness and precision. His lectures were prepared with great care and always kept up to date. His gentle manner and quiet sense of humour endeared him to his students.

His translation of Julius Schmidt's " Organische Chemie " was first published in 1926 and has now reached its fourth edition. This English version of " Schmidt " is not merely a translation of the original volume: many of the chapters were rewritten by Rule and later editions contained excellent summaries by him on such topics as chromatographic adsorption, steroids, vitamins, plastics, etc.

As previously mentioned, Rule was physically not strong and in 1922–23 he was incapacitated for a year and a half by rheumatic fever, which left him with a weak heart. Barred in consequence from active exercise, he enjoyed motoring and took special pleasure in driving through the countryside associated with Walter Scott and Robert Louis Stevenson.

In 1919 he married Elizabeth Cairns Rutherford, M.A., B.Sc., who gave him invaluable help in the preparation of the several editions of Schmidt, and devotedly nursed him during his long illnesses. The sympathy of Rule's many friends goes to her in her great bereavement.

JOHN E. MACKENZIE.
NEIL CAMPBELL.

RAYMOND TAYLOR.

1890—1943.

RAYMOND, third son of the late Frederick Taylor of Samuel Taylor and Company, the well-known Stourbridge chain and anchor manufacturers, was born at Brierley Hill, Staffordshire, on March 8th, 1890. He received his early education at Wolverhampton Grammar School, from which he won an open exhibition to Queens' College, Cambridge, in 1909. Two years later he obtained a First Class in Part I of the Natural Sciences Tripos and became a scholar of Queens'. Specialising in chemistry, he went on to Part II in 1913 and was placed in the second class. Before the outbreak of war he held an appointment as chemist at the iron and steel works of Messrs. Sanderson and Co., Middlesborough, but he relinquished this to enlist in the Royal Army Medical Corps. Obtaining a commission shortly after, he was first posted to the Durham Light Infantry, but on account of his scientific training he was later transferred to the Special Brigade of the Royal Engineers, newly formed for the prosecution of gas warfare. During 1915—16 he saw active service in France, where he was badly gassed by phosgene. Upon recovery he was passed for light duty only, owing to a permanent injury to the heart, and was sent to the Royal College of Science to work under Professor H. B. Baker on problems connected with gas warfare. On discharge in 1919, Taylor took up a post with Messrs. Albright and Wilson, Oldbury, but in 1921 he resigned to commence his long association with the Department of Scientific and Industrial Research.

His first assignment was to study the direct chlorination of methane and the initial academic work was carried out at Oxford under the supervision of Dr. D. L. Chapman. During this period Taylor was a member of Jesus College. The results of the investigation were embodied in a thesis for which he received the research degree of B.Sc. in 1922. For the purpose of carrying out large-scale work on the same subject, he was posted to the Royal Naval Cordite Factory, Holton Heath, where, remaining till the end of 1925, he was associated also with an investigation of methods for concentrating aqueous formaldehyde solutions. His last move was to the then newly-established Chemical Research Laboratory at Teddington, where, under the late Sir Gilbert Morgan, he was responsible for the development of researches involving the use of gases under high pressure. It was in this field, while studying the synthesis of methanol from carbon monoxide and hydrogen, that Taylor made what was probably his outstanding discovery, namely, that a notable proportion of ethyl alcohol could be obtained by suitable modification of the catalyst. On the basis of carbon content, up to 50% of the liquid product was isolable as ethyl alcohol, but unfortunately about half of the reacting carbon monoxide was simultaneously converted into methane. Outside of high pressure reactions, Taylor had many other chemical interests. He was early concerned in an investigation of Empire sources of helium, and developed a method for the dry assay and isolation of that gas from Travancore monazite. He also studied various addition compounds of boron trifluoride with organic esters, the azeotropic dehydration of alcohols with carbon tetrachloride, and an interesting thiocarbonyl of iron. The results of these and other investigations are described mainly in the publications of the Royal Society, the Chemical Society and the Society of Chemical Industry. Taylor was elected a Fellow of the Chemical Society in 1926 and a member of the Society of Chemical Industry in 1929. During 1940—41 he was Honorary Secretary of the committee of the London Section of the Society of Chemical Industry, and thereafter he remained a member of this committee up to the time of his death.

Among a wide circle of friends, Taylor will be remembered not only for his distinguished presence and courtly manner, but also for his utter selflessness and outstanding desire to serve. Although of great ability, he was somewhat reserved and showed great deference to the views of others. To his intimates, he was a tower of strength and his counsel was much sought after and valued. Taylor was a firm believer in the power of good and a great exponent of neighbourly duty. As an example may be cited his humanitarian work in the relief of Czech and Sudeten refugees; not only did he provide sanctuary for several, but he was personally instrumental in facilitating the escape of some of their relatives to this country. It is not too much to say that some of these refugees owe their lives to his efforts. This same desire to serve prompted him to become one of the earliest Air Raid Wardens in the Borough of Twickenham, and he remained an active civil defence worker to the end.

Essentially a lover of the beautiful, Taylor revelled in the open country, particularly the Cotswolds and North Wales, and was no lesss keen in his appreciation of flowers and foliage, the arts and the work of the craftsman and, not unnaturally, he was also a music lover. In 1915, he married Nettie Turquand, by whom, with their children Margaret (now Mrs. Ashley Bramall) and Paul he is survived. In recent years Taylor took a natural pride and a lively interest in his wife's many activities as a Councillor of the Borough of Twickenham.

He died on January 24th, 1943, after a brief but painful illness, endured with characteristic fortitude.

D. V. N. Hardy.