OBITUARY NOTICE.

FREDERICK MAURICE ROWE.*

1891—1946

FREDERICK MAURICE ROWE, Professor in the Department of Colour Chemistry and Dyeing at the University of Leeds, died on December 8th, 1946, at the age of fifty-five. He was born on February 11th, 1891, at Stroud in Gloucestershire where his father, H. J. Rowe, was engaged in business as a coal merchant and dealer in builders' materials, under the name of Wood and Rowe. From 1901 to 1908 he attended Marling School, Stroud, and always retained for it a strong attachment for which there were solid grounds. The school, founded and endowed in 1887 by Sir Samuel Marling, a prominent figure in the West of England cloth trade in that part of Gloucestershire, had attracted the attention of the Worshipful Company of Clothworkers by whose efforts a Department of Dyeing had been established at the Yorkshire College, Leeds. The Company decided to provide funds for an annual leaving scholarship to help a Marling School boy to proceed to Leeds for two years' technological training in textile dyeing at the College. Similar provision was made at Cheltenham Grammar School, and in consequence there were unusual opportunities for boys from Gloucestershire to go north for scientific and technical training whilst becoming familiar with another district famous for its woollen industry. On his mother's side Rowe was descended from a family of Huguenots who fled from France after the revocation of the Edict of Nantes in 1685 and settled in Gloucestershire to practise their craft of woollen manufacture with which some members of the family continued to maintain a connexion. This circumstance and the Cotswold environment may have helped to direct Rowe's choice of a career, but a love for chemistry was awakened in him by one of the masters at the school, Bartlett, whose influence in after years he frequently acknowledged with gratitude. The first holder of the Clothworkers' Scholarship for Marling School was R. J. Steele, who became a textile chemicals manufacturer in Bradford. A personal friendship between Steele's parents and Rowe's undoubtedly contributed to the result that in 1905 Rowe decided to work for the scholarship which would take him to Leeds, and three years later he duly became the sixth Marling Clothworkers' scholar, although he had at one time been described as the laziest boy in the school. It is hard to believe, however, that as a boy Rowe was ever consistently lazy, for the boy is father to the man, and the man was possessed of amazing industry. At school he distinguished himself at both work and games, and showed the personality of a leader by becoming Head Prefect.

Coming to Leeds as a young man of seventeen, a stranger in a strange place, Rowe at once found himself called on to make a major decision. The Yorkshire College had in 1904 become the University of Leeds, and a course had been established in Colour Chemistry and Dyeing, leading to a B.Sc. degree with Honours. This course, however, required three years, whilst the Marling Scholarship provided for two years only, and the holder had always been expected to follow a shorter course of study leading to a Diploma in Dyeing. Rowe's parents had kept him at Marling School at a considerable sacrifice and could not be called on for further help, but, nevertheless, he decided that the diploma was not good enough for him and that he must take the degree course, gambling on getting his scholarship renewed for a third year. The fight was a hard one, but in the end Rowe got his third year and made it secure for every Marling boy who subsequently went to Leeds.

Rowe spent five years at Leeds University where he acquitted himself with distinction, graduating with First Class Honours in 1911 and becoming President of the Union, besides receiving the Le Blanc medal and the award of a Clothworkers' Research Scholarship. This scholarship enabled him to start work under A. G. Green, then Professor in the Department and in the full tide of his researches on dyestuffs. At the end of a year's research Rowe gained his M.Sc. degree and a Clothworkers' Research Fellowship, but in the following year he decided to take an industrial research post with Messrs. Joseph Crosfield & Sons Ltd., the soap manufacturers of Warrington. This excursion into industry proved to be but a brief interlude in an academic career, although it had some importance for Rowe in that it provided him with an opportunity to spend a short time under Professor Freundlich in Brunswick studying colloid chemistry, and also gave him some acquaintance with manufacturing processes and with the properties of soap.

The ferment of war, however, brought Rowe finally back in 1916 to teaching and to dyestuffs. A. G. Green had gone from Leeds to Manchester where he was directing a Dyestuffs

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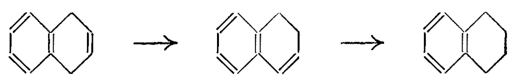
Research Laboratory at the College of Technology and at the same time assisting the firm of Levinstein Ltd. to extend its range of dye manufacture. Rowe became assistant to Green and lecturer in dyestuffs, and, two years later when Green severed his connexion with the College, head of the laboratory. During the following eight years Rowe laid the foundations of his researches and of his unique knowledge of dyes. In 1926 he was appointed Reader in Tinctorial Chemistry and Dyeing in succession to Dr. Edmund Knecht, but the same year there came to him the opportunity for which he had waited and hoped almost from the day he went to Leeds as a raw schoolboy. The retirement of A. G. Perkin created a vacancy in the Department of Colour Chemistry and Dyeing at Leeds, and Rowe had already made for himself such a position that he was the obvious choice for the Chair, which he held until his death.

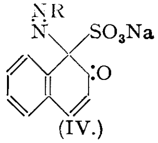
Rowe's life pursued a steady, placid course, marked by no violent changes or experiences, but occupied to the full with teaching, research, and service. He never seemed to have an idle moment. A tall man, of unusually handsome, commanding appearance, he inspired respect and confidence. To him his profession was a true vocation, a calling to which his life was devoted. Combined with a stern sense of duty and service he had a bull-dog persistence which gripped a problem until some sense had been worried out of it. This characteristic may have restricted the range of topics on which he concentrated in research, but these, once started, were pursued with great determination. Lacking the brilliance of some of his chemical contemporaries, he was second to none in the thoroughness with which his work was planned and the care with which it was executed and checked. He always had time for work, and during his last illness complained in a letter that he could no longer put in his customary sixteen hours a day. One of Rowe's lovable characteristics was his solicitude for his students. His department at Leeds was comparatively small, with an intake of about ten students each year. Rowe made it his business to know them all personally, to invite them to his house, and to learn their family and financial circumstances. The department was in fact, under Rowe, almost a family affair. He had a specially warm place in his heart for the scholars from Gloucestershire for whom he and Mrs. Rowe held a special party each year. He regarded it as his duty to the students and to the College to ensure that every one of them eventually found a suitable post, and in this he never failed. It was a tribute to his department's reputation, built up by his predecessors and maintained for twenty years by Rowe himself, that the demand for its students always exceeded the supply. The students were suited, as Rowe was proud of boasting, not only for posts with dyers or dye manufacturers, but for positions having nothing to do with colour, where the principal requisite was a sound scientific training. By his constant research activities in both pure and applied chemistry Rowe kept the attention of his students fixed on the importance of the experimental method and the inquiring mind for the advance of the technology for the practice of which they were training.

Those who knew Rowe's attitude to science best soon came to recognise that, although he was engaged all his life in the teaching and study of a technological subject, pure organic chemistry had an irresistible attraction for him and that he turned for preference to organic chemistry for research topics. He had a passion for the accumulation of facts and would spare no pains to verify them, leaving broad generalisations and theoretical speculations to others. Nevertheless, he recognised that the scientific development and appreciation of the technology of dyestuffs, their properties and application, could not be accomplished solely by the methods of organic chemistry, but required the application of physics and physical chemistry in increasing measure. In the Department of Textile Industries at Leeds, under the influence of Speakman, an important research school was growing up, and during the last fifteen years of his life Rowe joined with Speakman in researches demanding contributions from both the physical and the chemical side. During this period Rowe benefited much, on his own admission, from close contact with the Dyestuffs Division of Imperial Chemical Industries Limited, for whom he acted as consultant, serving for many years on a technological panel. This association with industry brought to his attention several problems which he attacked with his customary zeal.

Rowe's first researches were carried out in collaboration with A. G. Green at Leeds, arising out of Green's investigations of the constitution of stilbene dyes. They have been summarised by J. Baddiley in his admirable obituary notice of Professor Green and, since Rowe did not return to the subject, require no further mention here. On rejoining Green in Manchester he started work on the chemistry of tetralin derivatives with the ultimate object of determining whether *ar*-tetrahydro-α-naphthylamine and *ar*-tetrahydro-α-naphthol would have any value as dyestuff intermediates. Most of this work was done before the appearance in 1922 of Schroeter's comprehensive paper on tetralin. In the course of experiments on the reduction of α-naphthylamine by boiling it with sodium in presence of an alcohol, *ar*-tetrahydro-α-naphthylamine was produced only when the alcohol used was amyl, none when butyl or ethyl alcohol was used. Bamberger had made a similar observation when reducing naphthalene itself, finding that with ethyl alcohol dihydro-, and with amyl alcohol tetrahydro-naphthalene was formed. The prevailing view that temperature was the factor deciding how far reduction would proceed was disproved by Rowe by a series of careful experiments. He showed that the first reduction product of naphthalene by sodium and an alcohol is 1 : 4-dihydronaphthalene (I) which cannot be reduced further by sodium and any alcohol. When, however, this is heated with sodium alkoxide it is converted, at a rate increasing with the temperature and with the concentration of sodium alkoxide, into the isomeric 1 : 2-dihydronaphthalene (II), which can then be reduced further to tetrahydronaphthalene (III). When amyl alcohol is used, conditions favour the conversion of (I) into (II), and the reaction proceeds to the tetrahydro-stage. By an elegant series of experiments the same course was shown to be followed in the reduction of α-naphthylamine. The first reduction product was a dihydro-compound which gave (I) when the amino-group was removed and, therefore, must be 5 : 8-dihydro-1-naphthylamine. By prolonged boiling with sodium ethoxide this was converted into an isomeric compound which by elimination of the amino-group gave (II) and hence was either 5 : 6- or 7 : 8-dihydro-1-naphthylamine. The last compound, it was shown, could be reduced to 5 : 6 : 7 : 8-tetrahydro-1-naphthylamine even by sodium and ethyl alcohol, amyl alcohol not being required once the isomerisation had taken place (*J. Soc. Chem. Ind.*, 1920, **39,** 241T; Rowe and Levin, *J.*, 1920, **117**, 1574). Later it was shown that similar considerations applied to the reduction of α-naphthol, and the dihydro-α-naphthols obtained by reduction and isomerisation were identified by their preparation from the corresponding dihydro-α-naphthylamines (*J.*, 1921, **119**, 2021). With J. S. H. Davies, Rowe made a further study of the bromination and oxidation of 5 : 8-dihydro-1-naphthylamine (*J.*, 1922, **121**, 1000) and eventually published a description of a large number of azo-dyes in which *ar*-tetrahydro-α-naphthylamine and its 4-nitro- and 4-sulpho-derivatives had been used as components. Compared with corresponding dyes containing α-naphthylamine they were generally less deep in shade and showed no technical advantage (*J. Soc. Dyers and Col.*, 1925, **41**, 5).



(I.) (II.) (III.)

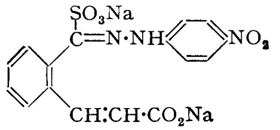


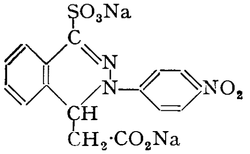
(IV.)

Rowe's most important contribution to chemical science arose out of an inquiry into the anomalous behaviour of β-naphthol-1-sulphonic acid with certain types of diazo-compound, resulting, as he discovered, in an unusual fission of the naphthalene ring followed by cyclisation with formation of heterocyclic ring systems. As early as 1918 he had studied the course of the reaction between β-naphthol-1-sulphonic acid and diazotised aromatic amines. The first product is a diazonium sulphonate which on treatment with a molecular proportion of sodium carbonate undergoes isomerisation to form the sodium salt of a derivative of β-naphthaquinone (IV). This, on treatment with acid, forms a true azo-compound of β-naphthol, with elimination of the sulphonic group. In this way, as Grant Hepburn showed, the well-known Para Red could be obtained from β-naphthol-1-sulphonic acid and diazotised *p*-nitroaniline. Interest in the reaction was intensified, however, by an observation by Grant Hepburn, made about 1921, that when the *p*-nitrobenzenediazonium β-naphthol-1-sulphonate was treated with excess of alkali an intense transient crimson colour appeared, and subsequent acidification produced only a trace of Para Red but a high yield of a new homogeneous yellow compound. At Grant Hepburn's request Rowe took up the study of this reaction, which led him into new chemical territory, the exploration of which occupied his attention for many years, indeed, until the end of his life.

It was soon established that the new reaction only occurred when the diazonium compound used contained a strongly negative substituent, generally a nitro-group. Attention was at first concentrated on the compound from *p*-nitrodiazobenzene, from which many degradation products were obtained and analysed by Miss E. Levin, who was Rowe's able assistant at this time, but for long the nature of the chemical changes which were occurring eluded the investigators. At length, however, one of the degradation products gave by oxidation with chromic acid two identifiable products, phthalimide and benzoquinone, and it at once became clear that fission of the naphthalene ring had occurred and a new ring system had been set up from which eventually had been obtained *p*-aminophenylphthalimidine, the compound which by oxidation had given phthalimide and benzoquinone. From the analyses of the intermediate compounds it was not difficult to construct the whole story which was published in 1926 (*J.*, 1926, 690). Subsequent work with other diazo-compounds confirmed the original conclusions, only a few minor modifications of the formulæ first suggested for some of the products having to be made.

(V.)



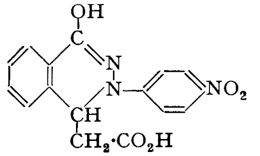


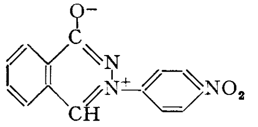
(VI.)

The first action of excess of alkali on the quinone sulphonate (IV) is to cause fission of the naphthalene ring between C^1 and C^2 with formation of a phenylacrylic acid derivative (V), which is responsible for the intense colour, but this quickly changes by cyclisation to the phthalazine derivative (VI). Compound (V) was at first hypothetical, but some years later the corresponding *o*-nitro-compound was isolated and characterised, being obtained from sodium 1-(*o*-nitrobenzeneazo)-β-naphthaquinone-1-sulphonate (Rowe *et al.*, *J.*, 1935, 1796).

From compound (VI) a bewildering family of new compounds was obtained, only a few of which can be noted here. The sulphonic acid group was removed by boiling the compound with hydrochloric acid; sulphur dioxide was evolved and the hydroxy-compound (VII) was formed. This by boiling with 50% sulphuric acid lost acetic acid to give the phthalazone (VIII) which by reduction gave successively the aminophthalazone (IX) and *p*-aminophenylphthalimidine (X). Alternatively (VII) could first be reduced to the aminophenyltetrahydrophthalazine

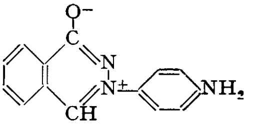
(VII.)

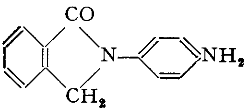




(VIII.)

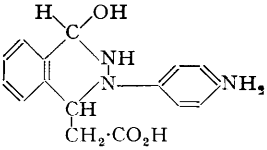
(IX.)

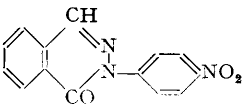




(X.)

(XI.)



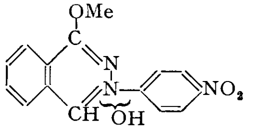


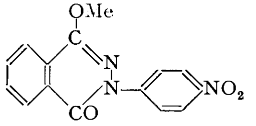
(XII.)

(XI) which on boiling with mineral acid gave (IX). There was at first some doubt about the constitution of (VIII) since it might have been the isomeric 3-*p*-nitrophenylphthalaz-4-one (XII) which was, however, synthesised by an unambiguous route and found to be different. The phthalazone (VIII) could be methylated to form the methosulphate of a base, probably (XIII), which combined with ethyl alcohol to form an unstable compound which changed, on being heated, to 4-keto-1-methoxy-3-*p*-nitrophenyldihydrophthalazine (XIV), which was demethylated to (XV). This reaction was not explained, but the constitution of (XV), which is identical with 1 : 4-diketo-3-*p*-nitrophenyltetrahydrophthalazine, was confirmed by preparing it from phthalyl-*p*-nitrophenylhydrazide (XVI) by the method of Chattaway and Tesh (*J.*, 1920, 712). Since by alkylation (XV) gives (XIV) and not an *N*-methyl derivative, it was concluded that it is best represented as a hydroxy-ketone, not as a diketone (*J.*, 1935, 1808).

Another interesting series of compounds was obtained from compound (VII) by oxidation with cold chromic acid. With this reagent, instead of loss of acetic acid, decarboxylation occurred with formation of the 4-methyl derivative of (VIII), namely 3-*p*-nitrophenyl-4-methylphthalaz-1-one (XVII), a golden-yellow crystalline substance. This compound proved to be of considerable chemical interest. Like the phthalazone (VIII) it could be methylated to a methosulphate, but this on basification was transformed into a methylene compound (XVIII). Unlike most other known methylene bases, which are non-crystalline and unstable, this was stable and crystalline, as were corresponding compounds containing *o*-Cl, 2 : 6-Cl_2, 2 : 6-Br_2, and *o*-Me as well as the 4-NO_2 group. Their basicity is low, and of their salts only the perchlorate could be obtained pure, but they had most of the properties of other pseudo-bases. They were studied in much detail, and from them were prepared many methine dyes, some of which functioned as photographic desensitisers. The methylene bases are oxidised by nitrous acid and by *p*-nitrosodimethylaniline to ketones of type (XIV).

(XIII.)





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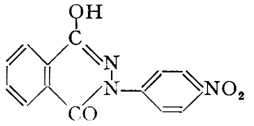
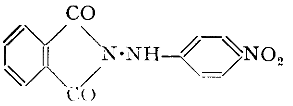
(XV.)





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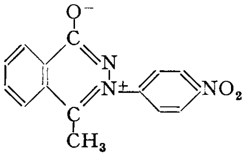

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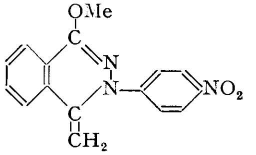

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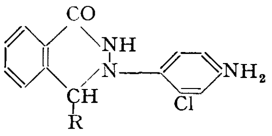
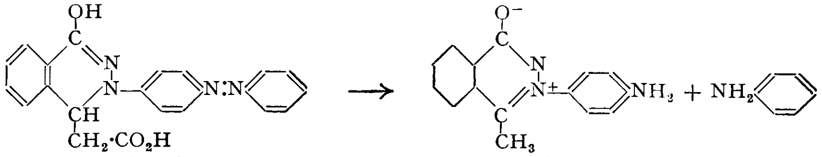


(XIX.)

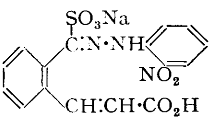
Some interesting new features were discovered when, instead of *p*-nitrodiazobenzene, other diazo-compounds were used. For instance, using *o*-chloro-*p*-nitrodiazobenzene, an intermediate reduction stage between (IX) and (X) was realised with formation of the ketotetrahydrophthalazone (XIX, R = H or Me) which was difficult to reduce to the phthalimidine.

When 4-aminoazobenzene was used for diazotising and reacting with β-naphthol-1-sulphonic acid, only a small yield (19%) of the phthalazine compound could be obtained, the principal product always being benzeneazobenzeneazo-β-naphthol, but 4′-nitro-4-aminoazobenzene gave a much higher yield (63%). The benzeneazophenyl derivative (XX) and its *p*-nitro-derivative showed remarkable behaviour in that, when boiled with dilute sulphuric acid, they did not lose acetic acid, but underwent decarboxylation and simultaneous fission of the azo-group, giving (XXI) and aniline or *p*-nitroaniline. Rowe considered that the splitting of the azo-group was primarily a hydrolysis, not a reduction, since the azo-group should not be reduced in preference to the nitro-group (*J.*, 1932, 1118). It is significant, however, that in absence of the azo-group an equivalent amount of an oxidising agent is necessary to bring about the change, as in the conversion of (VII) into (XVII). The observation led Rowe later to examine carefully the behaviour of simpler azo-compounds with acids (see p. 2329).



(XX.) (XXI.)

Experiments in which *o*-nitroaniline (or its 4-chloro- or 4-methyl derivative) was used gave especially interesting results, not only because, as already mentioned, primary ring-fission products, derivatives of phenylacrylic acid, were isolated, but because alternative cyclisation products from these were discovered. The action of concentrated sodium hydroxide solution on sodium 1-*o*-nitrobenzeneazo-β-naphthaquinone-1-sulphonate is immediately to split the naphthalene ring with formation of sodium benzaldehyde-*o*-nitrophenylhydrazone-ω-sulphonate-2-β-acrylic acid (XXII). This cyclises only slowly to the phthalazine derivative, and by quick acidification followed by neutralisation with sodium carbonate it can be isolated. This compound when boiled with dilute acid is converted with loss of sulphur dioxide into the *o*-nitrophenyl-



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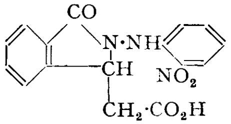

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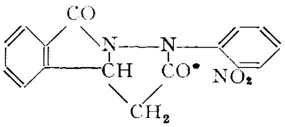

(XXIV.)

hydrazide of *o*-carboxyphenylacrylic acid which is cyclised by heat or boiling sodium carbonate solution into a new ring compound, 2-(*o*-nitrophenylamino)*iso*indolinone-3-acetic acid (XXIII). This again undergoes further cyclisation when boiled with acetic anhydride to (XXIV) which is, however, readily hydrolysed by acids back to (XXIII). Still another ring-closure was achieved by reducing the nitro-group (XXIV), the resulting amino-group condensing with the neighbouring carbonyl group.

There is no need to discuss every paper in the series, which appeared under the title " A new reaction of certain diazosulphonates derived from β-naphthol-1-sulphonic acid ", but reference must be made to a posthumous paper with A. T. Peters in which it is shown that, in spite of what was said in the first paper, phthalazine formation can be brought about from 1-benzeneazo-β-naphthaquinone-1-sulphonate; in other words a strongly negative group in the amine used for diazotisation is not necessary, but the reaction must be carried out under carefully controlled conditions.

Although Rowe published in collaboration with his students and staff a number of other researches in pure organic chemistry, none had the sustained interest or the novelty of that just described. They had the common factor that they concerned substances, aromatic in character, of possible interest as dyestuff components, as exemplified by papers on *tert.*-butylanthraquinone, *tert.*-butylnaphthalenes, benzoylacenaphthene, and derivatives of tetrachlorobenzene.

Rowe's technological work was concentrated for a long period on azo-dyes, particularly the group of insoluble colouring matters used as pigments or as dyes when produced on the fibre. He developed their analysis and identification to a high degree, and devoted much time to the study of their behaviour on the fibre under conditions to which they were likely to be subjected in practice. Such dyes, frequently called " azoic " dyes, are obtained by coupling a diazotised aromatic amine with β-naphthol or with the anilide or a substituted anilide of 2-hydroxy-3-naphthoic acid. Products for the formation of these colouring matters in dyeing and printing processes were being brought on to the market under trade names by German firms in the years following 1918, and Rowe made it his business to discover all he could about them. He rendered service to the industry by publishing the constitutions of many of the bases and Naphtols (the generic name for arylamides of 2-hydroxy-3-naphthoic acid), and, to assist others to identify the bases, published a table giving the melting point, crystalline form, and colour reactions of azo-dyes obtained by coupling the diazotised bases with β-naphthol and 2 : 3-hydroxynaphthoanilide (Naphtol AS) (see Rowe and Levin, *J. Soc. Dyers and Col.*, 1924, **40**, 220, and numerous other papers in this journal between 1921 and 1930). Rowe's knowledge in this field fitted him particularly for the task of expert witness in the important patent action brought by Imperial Chemical Industries Limited against I.G. Farbenindustrie in 1930. The patent action in question was a petition by I.C.I. for the revocation of certain patents granted to the I.G. on grounds of priority of publication, common knowledge, and insufficiency of description. At a much earlier date, during 1912—1914, Chem. Fab. Griesheim-Elektron had patented the manufacture and use of a wide range of arylamides of 2 : 3-hydroxy-naphthoic acid, for the preparation of azo-dyes as pigments or on the fibre; much later the I.G. had obtained the patents now petitioned against, covering certain selected members of the same group of compounds, on the grounds that these selected members had peculiar advantages in giving specially fast dyes, notably fast to keir boiling. (Keir boiling is a process in which cotton goods, frequently already printed with a coloured pattern, are boiled with dilute caustic soda solution to bleach the white cotton; the colouring matter should be as nearly as possible unaffected.) Rowe's task in this case was to test experimentally the defendants' claim, which he did by preparing some hundreds of samples of cotton dyed with colouring matters made from the intermediates claimed in the later patents and comparing them with others made from other intermediates not amongst the selected ones, but covered by the earlier patents. The Germans had not specified any particular test to justify their claims for the selected compounds, and Rowe used a test which had been recommended by a German Fastness Commission. Rowe showed such skill in putting his experimental findings before the court, and in pointing out the inadequacy of experimental tests put forward in evidence by the defendants, that the judge was convinced beyond a shadow of doubt that the special claims of the patents in dispute were unwarranted, and they were, in fact, revoked. This case is of special importance in regard to future chemical patents since, in the course of his judgment, Mr. Justice Maugham defined for the first time the requirements of a valid selection patent.

Characteristically, Rowe was not content with the empirical experiments which the patent case had necessitated, but went on to inquire more deeply into the changes taking place with dyes which were not fast to the keir-boiling test. He had already published some results having a bearing on the problem, in which he had shown that boiling soap solution causes insoluble azo-dyes on cotton to aggregate into coarse crystalline particles visible under the microscope, some of the dye being removed entirely from the fibre. This aggregation produces a change not only in the depth of the dyeing, but also in its hue and fastness to light and rubbing, besides causing dyed viscose to lose lustre (*J. Soc. Dyers and Col.*, 1926, **42**, 207; 1929, **45**, 67). In the keir-boiling test, which is a prolonged boil with 0·36% aqueous caustic soda, not only can this physical transformation occur, but also hydrolysis of an amide group and reduction brought about by the cellulose. Reduction may occur at the azo-group, and nitro-groups, if present, are usually affected so that no dye containing this group stands up to the keir-boiling test. The exact course of these chemical changes is affected by the constitution of the dye, especially by the orientation of nitro-groups, and much careful quantitative work was done in which decomposition products were isolated and identified (*ibid.*, 1931, **47**, 29; Rowe and Ueno, *ibid.*, 1931, **47**, 35; Rowe and Jowett, *ibid.*, 1931, **47**, 163; Rowe and Giles, *ibid.*, 1935, **51**, 314).

Rowe also started an investigation of the decomposition of azo-dyes by hot aqueous sulphuric acid, having been led thereto by the curious behaviour of some phthalazine compounds containing the benzeneazophenyl group as a substituent (see p. 2327). Several types of azo-compound were found to undergo fission at the azo-group with regeneration of the amine originally used as the diazo-component, but the other fission product could not be identified and the mechanism remains obscure. That the reaction is complex is shown by the observation that Orange I gives some α-naphthaquinone and Orange II some hydroxy-α-naphthaquinone (Rowe and Dangerfield, *J. Soc. Dyers and Col.*, 1936, **52**, 48).

During the later years of his life Rowe became more and more convinced, through his industrial contacts, of the importance of investigating technological phenomena and processes from the scientific point of view, and that such studies were suitable and proper for the Technological Department of a University. He would have proceeding at the same time in his laboratories chemical studies of new products made available by industry, such as *m*-5-xylenol or 1 : 2 : 4 : 5-tetrachlorobenzene, and technological studies such as that of a new process for stripping dyes from a fibre involving the use of a higher aliphatic ammonium compound (Rowe and Glyn Owen, *J. Soc. Dyers and Col.*, 1936, **52**, 205). He investigated the phenomenon of the fading of dyeings of certain dyes on acetate rayon when exposed to burnt gas fumes. The dyes affected are aminoanthraquinones and strong evidence was found that the fading is due to the presence in the burnt gas fumes of oxides of nitrogen which react chemically with primary and secondary amino-groups.

In 1935 he commenced in conjunction with Speakman a series of researches on the dyeing of wool in which the techniques which Speakman had developed for the experimental study of keratin fibres, and Rowe's flair for painstaking chemical work, were happily blended. With the help of E. Race they developed a major inquiry into the phenomenon of unlevel dyeing of wool. It was known that exposure of wool to light and air affected its dyeing properties, this fact being shown, for instance, when a wool hair is found to be dyed more heavily at the tip end than at the root end. A consistent explanation of the observed facts was found in the assumption that exposure of wool leads to a partial breakdown of the disulphide bonds between the protein chains, resulting in changes in both its physical and chemical properties. Exposed fibre swells to a greater extent in water than the unexposed and consequently becomes more accessible to dye molecules. When the latter are colloidal they are fixed permanently in the fibre, and consequently tips of the wool staple are more heavily dyed than the root end; when they are crystalloid they first dye the tip more heavily, but can escape more readily from the more swollen end in the levelling process and eventually become more concentrated in the roots; consequently, crystalloid dyes colour the roots more heavily than the tips. Chemically, exposed fibres or parts of a fibre contain reducing groups, such as aldehyde and sulphhydryl groups, which have a reducing action on dichromate; consequently, exposed wool fixes more tervalent chromium than unexposed wool, and the shade of an after-chromed dye is affected by this difference. These findings were confirmed by a number of ingenious experiments, whilst on them were based devices by which the tips and roots could be dyed a level shade. Acid dyes can be caused to dye level shades by adjusting the degree of dispersion of the dye by suitable additions to the dye bath. Alternatively, if the fibre is treated with chromium acetate, the chromium makes new linkages between the peptide chains in place of the disrupted disulphide linkages, and the swelling power of the exposed wool is reduced and its dyeing properties brought to approximate equality with those of unexposed wool (*J. Soc. Dyers and Col.*, 1938, **54**, 141, 159). Although this treatment with chromium acetate is carried out in presence of acetic acid, the most effective salt to use is a basic acetate in which the molecular ratio of acetate to chromium is 2 : 1, and which has been aged. Many different forms of chromium acetate were investigated, and an analytical method was devised for characterising them (*J. Soc. Dyers and Col.*, 1939, **55**, 69).

One of the last pieces of work started by Rowe was an investigation of the process of dyeing cotton, especially for heavy military equipment, in khaki colour by means of a mixture of chromium and iron oxides. One cannot imagine Rowe undertaking such a piece of inorganic research had he not regarded it as part of his contribution to the war effort. The work, carried out in association with Speakman and Race, involved a thorough investigation of the properties of the so-called iron and chromium chromates and their behaviour with water, of the composition of the pigment formed when a mixture of iron and chromium salts is treated with alkali or a chromate, and especially of the effect of the mineral deposit on the strength of the cotton. Finally a method was invented for rendering the cloth immune to fungus attack by causing some copper carbonate to be precipitated along with the khaki pigment. The results of this work have been published (*J. Soc. Dyers and Col.*, 1941, **57**, 213, 257; 1942, **58**, 32, 161; 1945, **61**, 224, 233, 310; 1046, **62**, 9, 19).

Apart from his scientific papers Rowe's literary output was not great. He translated Reinthaler's " Die Kunstseide und andere seidenglänzende Fasern " under the title " Artificial Silk ". Amongst several reviews of the different aspects of dye chemistry his most useful contribution was " The development of the chemistry of synthetic dyes, 1856—1938 ", presented in the form of lectures to the Institute of Chemistry and published by that body. It forms a very useful compact text-book of the chemistry of dyes. His Perkin centenary lecture (" The Life and Work of Sir William Henry Perkin ") and obituary notice of Arthur George Perkin, both for the Society of Dyers and Colourists, are sympathetic accounts of father and son both famous in dyestuff history.

During all his working life Rowe was closely associated with the Society of Dyers and Colourists, of which he became a member in 1917. Of his many services to the Society the most important was undoubtedly the editorship and production in 1924 of the " Colour Index " and the Supplement thereto in 1928. Before the publication of this work, those concerned with commercial dyestuffs had to rely for collected information on the German work, Schulz's " Farbstofftabellen ". A book of reference in English was badly needed, apart from the fact that the changes in the dyestuff industry resulting from the war of 1914—1918, and the rapid expansion of the range of dyestuffs had put Schulz entirely out of date. The collection and verification of the mass of data included in the " Colour Index " was an amazing feat of industry and patience; as an example of the care he took, he personally checked every patent reference. Rowe served on the Publication Committee of the Society from 1922 to 1946, and was joint editor of its *Journal* from 1933 to 1942, and editor from 1942 until his death. Rowe's temperament was particularly fitted for editorial work; indeed his colleagues well knew that his first reaction to any report or document was more likely to be that of the critical editor than the scientist. He maintained the standard of the *Journal* at a very high level, and his production of the special Jubilee number in 1934 was particularly successful. He served on the Council of the Society from 1924 to 1929, in which year he became a Vice-President, and in 1944 the Society paid him the honour of making him an Honorary Member. He joined the Chemical Society in 1918 and served on its Council from 1931 to 1934. He became a Fellow of the Institute of Chemistry in 1921, the same year in which the University of Leeds granted him the degree of D. Sc. Besides receiving four times the award of the Dyers' Company's Medal for the best paper of the year in the *Journal of the Society of Dyers and Colourists*, he was presented with the Society's Gold Medal in 1934 for his services. In 1932 he became a Liveryman of the Worshipful Company of Dyers, and in 1944 received the honorary Freedom and Livery of the Worshipful Company of Clothworkers.

His election to the Fellowship of the Royal Society in 1945 gave him the greatest satisfaction, especially so because his life was already overclouded by illness which was restricting his activity. He did indeed manage to go to London to be admitted to the Royal Society in May 1945, the last considerable journey he made. For the last three years of his life Rowe put up a truly heroic struggle against an affection of the kidneys involving growing disability, intense physical discomfort, and susceptibility to all kinds of minor ailments. His health had probably suffered because, out of an intense spirit of patriotism, he had in 1940 taken a commission in the Home Guard, thereby involving himself in night military exercises in addition to his already heavy daily duties. He refused to give in and undoubtedly prolonged his own life by applying his scientific knowledge to the treatment of his condition. Almost to the last he worked to write up an account of his researches whilst time remained. He loved life for what he could give to it, not for what he could take, and when he could no longer give he laid it down.

He married, in 1916, Mary Nield Cockburn, youngest daughter of Sir George and Lady Cockburn of Leeds, who survives him.

E. H. RODD.