# OBITUARY NOTICES.

## PAUL BORG.

### 1888—1936.

PAUL BORG was born in Malta on November 30th, 1888. He matriculated in the Malta University in 1906, and attended the academical course of science for the next three years. In 1909 he qualified as chemist and pharmacist; subsequently he applied himself to the study of chemistry, entomology, and plant pathology, and succeeded in elucidating numerous obscure points in the life history of insect pests and fungous diseases. In 1919 he published an illustrated booklet on " The Scale-insects of the Maltese Islands," giving also in detail the various methods of treatment.

In 1920 Borg was appointed plant pathologist to the Department of Agriculture, and at once started an extensive campaign for the reconstitution of vineyards destroyed by the *Phylloxera*, for the establishment of nurseries of American vines, with a view to providing ample supplies of suitable stock for grafting, and for the treatment of insect pests and plant diseases, particularly scale-insects, woolly aphis, fruit-tree borers, and the fruit-fly, and the fungous diseases of the vine and the potato.

In 1921, at the suggestion of Lord Blyth, and under the auspices of the Colonial Research Committee, Borg was entrusted with an investigation into the wine-making processes obtaining in Portugal (the districts of Estremadura and the Alto Douro), in Spain (Jerez de la Frontera, Malaga, Barcelona, Reus, and Villafranca), in France (the region of Bordeaux), and in Algiers and Tunis. The object was primarily the study of the liqueur wines as produced in Spain and Portugal, and of the table wines of Bordeaux. The tour of inspection lasted four months, and on his return to Malta, Borg collected the various reports which he had submitted to Lord Blyth, and published at the Government Press his " Report on a Tour of Inspection in the Wine-growing Districts of Western Europe and Algeria," teeming with valuable information and conveying an insight into trade secrets, particularly in the production of the superior brands of sherry.

Borg, who was apparently in good health, succumbed to a sudden attack of angina pectoris, early in the morning of May 7th, 1936.

J. BORG.

## THOMAS ELLISS CLARKE.

### 1914—1936.

CLARKE was born in Manchester on August 23rd, 1914. The North Manchester Municipal High School was inaugurated in 1926, and he was one of its first pupils. He matriculated in the Northern Universities in 1930, and obtained their Higher School Certificate in 1932. He was offered, but did not take up, a scholarship at the Manchester College of Technology, preferring rather to come to London and study for the teaching profession. He accordingly entered King's College in the autumn of that year, with the assured prospect of a session at the Institute of Education subsequent to his undergraduate course. Originally he had meant to study physics and, at the conclusion of his Intermediate Science year, any of the Departments of Mathematics, Physics, and Chemistry would gladly have accepted him as a student. He actually decided on chemistry, and during the next two years it became evident that chemical industry would have been the career of his choice if he had been a free agent. He graduated with Honours in 1935 and, after a certain degree of hesitation, decided to proceed with his Teachers' Diploma course, as was normal for a man in his position. At first, he attempted to combine with this work research in physical chemistry at the Battersea Polytechnic, but was compelled to stop the latter, as being deemed inconsistent with his education studies. He was taken ill in July, 1936, and died early in August.

Clarke was a man of solid character, with good physical presence, a diffident and rather charming personal manner, an essentially sane and balanced mind, and a generous and attractive nature. He won golden opinions during his schooldays, and his headmaster had always hoped that he would return to the school as a member of the staff. Indeed, he had in high measure those qualities which go to make a good schoolmaster, qualities which made him much appreciated during his college career, at the Institute of Education and at St. Paul's School, where he carried out his teaching practice. He inspired in his friends an unusually warm attachment, and all who knew him regret the tragic end to his brief career.

A. J. Allmand.

## VICTOR GRIGNARD.

### 1871—1935.

François Auguste Victor Grignard, who was elected to the Honorary Fellowship of our Society in 1920, was the son of Théophile Henri Grignard, a sail maker of Cherbourg. After receiving his early education at Cherbourg and Cluny, he entered at the University of Lyons and secured his licentiate in due course. At first, Grignard proposed to specialise in mathematics, but, inspired by Bouveault, then a junior lecturer in chemistry at Lyons, he decided to specialise in organic chemistry.

Grignard's first investigations were carried out in 1898 and 1899 and described in three short papers on "ethyl β-*iso*propylacetobutyrate and the stereoisomeric di*iso*propylbutenedicarboxylic acids" (with Barbier), "a new sexavalent hydrocarbon: 2-methyl-3-hexene-5-ine," and "2-methyl-4-heptene-6-ine and 2-methyl-4 : 5 : 6-heptatriene." The last two were studies of mixed ethylenic and acetylenic hydrocarbons, classes of compounds which formed the basis of much of Grignard's subsequent original work.

Grignard's work on organo-magnesium compounds began in 1899 and arose from Barbier's assigning to him the further study of the action of magnesium in the presence of methyl iodide on methylheptenone. Barbier himself had obtained the corresponding tertiary alcohol, dimethylheptenol, by using magnesium in place of zinc as in Saytzeff's method and had thus demonstrated that magnesium and alkyl iodides could be used to react with ketones whereas zinc cannot be employed in these conditions. In repeating Barbier's work, Grignard obtained the same inconsistent and irregular results as Barbier and it occurred to him that these might be avoided by preparing the organo-magnesium compound separately and then allowing it to react with the compound containing the functional group. He was, of course, familiar with the results obtained by Lothar Meyer and his pupils on the magnesium alkyls, which were described as infusible solids sparingly soluble in neutral solvents and spontaneously inflammable in air and carbon dioxide. He also knew that Frankland and Wanklyn had shown that the zinc alkyl halides had synthetic applications similar to those of the zinc alkyls, although they generally react more sluggishly, but Grignard anticipated that magnesium, being more electropositive than zinc, would react more easily and completely than the latter metal with alkyl halides. The great discovery that magnesium in the presence of anhydrous ether reacts with alkyl halides at the ordinary temperature, giving rise to the magnesium alkyl halides (organo-magnesians, to translate the French general and convenient expression for these compounds), many of which are very soluble in ether, followed almost at once.

The first publication of Grignard's discovery was made in a short paper communicated by Moissan to the Académie des Sciences on 11 May, 1900 (*Compt. rend.*, 1901, **132**, 336) and the immediate applications of such elegant and simple reagents were quickly developed by the author himself. Even at this time, Grignard, working without assistance, exhibited outstanding qualities of hard work and tenacity which amounted to genius and which always impressed those with whom he came into contact. In July, 1901, at the age of 30, Grignard presented his work on the organo-magnesians for the degree of Docteur ès-Sciences de Lyons, his examiners being Barbier, Gouy and Vignon. Grignard declined Moissan's invitation that he should present his thesis at Paris; he preferred to dedicate it to his own university where the discovery had been made and from which he had received so much help and inspiration. Speaking at the funeral of Grignard, Professor

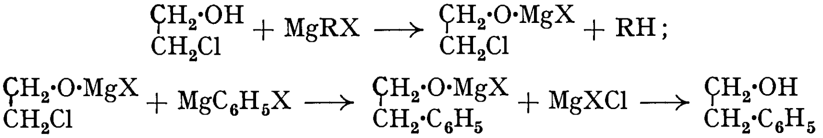
Urbain said, " Les débuts de Grignard sont sans doute uniques dans l'histoire des sciences chimiques. Dès sa seconde publication, il annonce l'une des plus grande découvertes qui ait été faite dans le domaine de la chimie organique et il faut remonter aux fondateurs de cette science pour trouver l'example d'une aussi remarquable précocité d'un génie créateur cultivant les sciences expérimentales."

The importance of the discovery made by the young Grignard was quickly appreciated in France; he shared the Cahours prize of the Académie des Sciences with Fosse in 1901 and with Fosse and Marquis in 1902, in which year he also received the Berthelot medal. The wide scope of the reactions of the Grignard reagents made it impossible for any one investigator to explore all their reactions. The new reaction opened up an almost illimitable field of investigation to organic chemists generally. Some might perhaps have resented the exploitation of a discovery by so many others; Grignard, however, only regarded this in the light of collaboration and derived much satisfaction in the research activity which was based on or extended by his own original work.

In the investigations of the reactions of the organo-magnesians he had, as his first chief collaborator, Tissier, who was lecturer on chemistry and also a Senator. With him, Grignard published several papers in the *Comptes rendus* dealing with the synthesis of primary alcohols starting with trioxymethylene and the synthesis of tertiary alcohols from acid chlorides, carbonyl chloride and anhydrides. It was soon realised that the ketones are intermediate products in the latter reactions and that the ketone can only be isolated in particular cases and by checking the reaction by strong cooling.

At an early stage, Grignard investigated the action of his reagents on compounds of multiple function, in the first place the ketonic esters. In normal cases the ketonic group is the more reactive and it is thus possible to isolate tertiary alcohol-esters. If the reaction is carried to completion, Grignard showed that di-tertiary alcohols are produced, and, as shown by various other investigators, this reaction may be used for effecting asymmetric syntheses.

The constitution of the Grignard reagent has been much discussed and it would appear now that Meisenheimer's co-ordination formula $\begin{smallmatrix}\text{Et}_2\text{O}\\ \text{Et}_2\text{O}\end{smallmatrix}\!\!>\!\text{Mg}\!<\!\begin{smallmatrix}\text{X}\\ \text{R}\end{smallmatrix}$ agrees best with the observed facts, and analogous constitutions are assigned to the reagents in the presence of tertiary amines which may replace the ether normally employed. The inconclusive discussion between Grignard and Blaise was, however, useful because it led to the study of the reaction between organo-magnesians and ethylene and other glycol oxides. In this particular investigation, Grignard prepared β-phenylethyl alcohol by the following series of reactions:



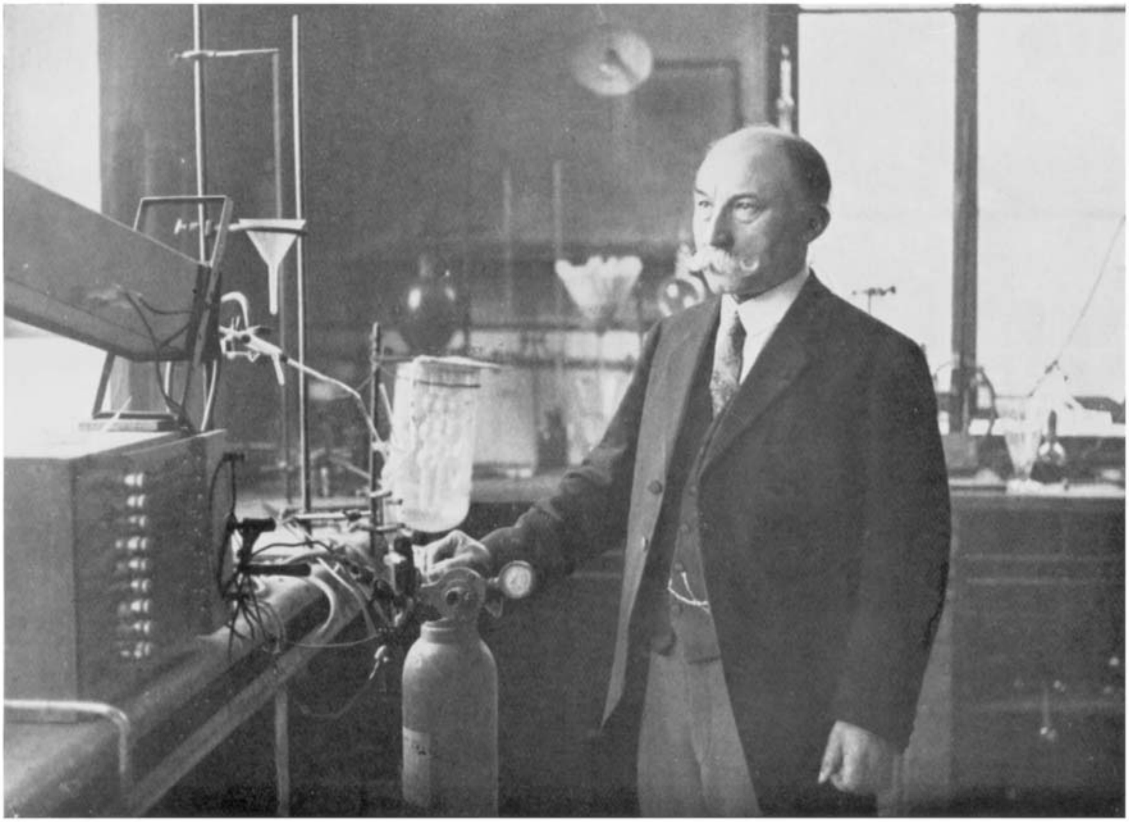
$$\begin{array}{l}\text{CH}_2\cdot\text{OH}\\ \text{CH}_2\text{Cl}\end{array} + \text{MgRX} \longrightarrow \begin{array}{l}\text{CH}_2\cdot\text{O}\cdot\text{MgX}\\ \text{CH}_2\text{Cl}\end{array} + \text{RH};$$

$$\begin{array}{l}\text{CH}_2\cdot\text{O}\cdot\text{MgX}\\ \text{CH}_2\text{Cl}\end{array} + \text{MgC}_6\text{H}_5\text{X} \longrightarrow \begin{array}{l}\text{CH}_2\cdot\text{O}\cdot\text{MgX}\\ \text{CH}_2\cdot\text{C}_6\text{H}_5\end{array} + \text{MgXCl} \longrightarrow \begin{array}{l}\text{CH}_2\cdot\text{OH}\\ \text{CH}_2\cdot\text{C}_6\text{H}_5\end{array}$$

β-Phenylethyl alcohol is used in artificial rose perfume and this was the first industrial application of Grignard's work.

So far, Grignard's work had been carried out at Lyons, where he held a position which may be described as that of an assistant lecturer, but in November, 1905, he became lecturer at Besançon, where Boutroux, a pupil of Pasteur, was professor and was still investigating vine-must. At Besançon, Grignard carried on his investigations under restricted conditions, but began the study of the action of the reagents on thionyl chloride, thus providing a useful method for the preparation of sulphinones or sulphoxides; he returned to Lyons in the following year to collaborate again with Barbier and to direct the researches of his own co-workers.

By this time, 1906, many investigators had made considerable use of the Grignard reaction not so much for the preparation of compounds hitherto difficult of access but in the determination of constitution, and Grignard with Barbier now began to use his reagent for similar purposes. By the exhaustive hydration of French ' pinene ' (action of benzene-



V. Grignard

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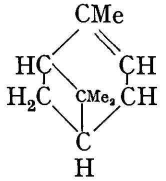
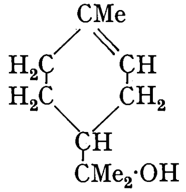
sulphonic acid in acetic acid and hydrolysis of the resulting acetyl derivative) the α-pinene is converted into α-terpinol (m. p. 35°) :

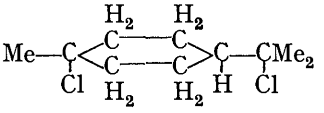




From the final residue, Grignard isolated for the first time from such a French source, camphene (m. p. 42°) and showed that *l*-limonene, dipentene (*dl*-limonene) and terpinolene were also present. Perhaps only workers in this field of organic chemistry can appreciate with what difficulties such work at that time was attended.

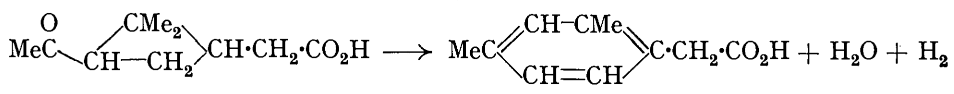
Grignard next investigated the solid and liquid pinene hydrochlorides which had been described by Barbier in 1883. He showed that each of these hydrochlorides reacts with magnesium and by oxidation and subsequent decomposition of the magnesium derivative of the liquid hydrochloride obtained a mixture of alcohols having the formula $C_{10}H_{18}O$, among which the chief are borneol and fenchyl alcohol. By the action of carbon dioxide on the same magnesium derivative, Grignard isolated an acid, $C_{11}H_{18}O_2$, together with a complex terpene and a hydrocarbon, $C_{20}H_{34}$, indicating the joining together of the original radicals under the action of magnesium. By the oxidation of the magnesium derivative of the solid hydrochloride, Grignard obtained a mixture of borneol and *iso*-borneol and by the treatment of the same magnesium derivative with carbon dioxide he isolated what we now know to be *cis*- and *trans*-camphane-2-carboxylic acids.

In investigating the action of magnesium on dipentene dihydrochloride (of which two, *cis*- and *trans*-, forms are known), Grignard showed that this compound behaves similarly to αε-dibromopentane, in giving a dimagnesium derivative. Under the influence of the



metal two molecules of hydrogen chloride may be lost with the regeneration of dipentene; further, two monomagnesium derivatives may be formed, proving the removal of a molecule of hydrogen chloride in two different directions. The action of carbon dioxide on the magnesium derivative of the crude dihydrochloride gives rise to two monocarboxylic acids and the two stereoisomeric dicarboxylic acids indicated by theory. The dehydration of the *cis*-dicarboxylic acid led to the synthesis of a ketone, $C_{11}H_{16}O$, indicating a loss of two hydrogen atoms, whereas the formation of a ketone, $C_{11}H_{18}O$, might ordinarily be expected.

In collaboration with Barbier, Grignard prepared the *l*- and *d*-pinonic acids in a state of purity and described their properties in detail. The former prepared by the oxidation of *l*-pinene differed from that obtained by Tiemann by oxidising sodium *l*-α-campholenic acid and distilling the *l*-α-dihydroxydihydrocampholenic acid. By the action of bromine in the presence of water at 200°, Grignard was able to convert pinonic acid into *m*-xylene-4-acetic acid, the following reaction taking place :



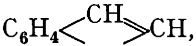
This is an interesting example of the conversion of a terpene into an aromatic derivative.

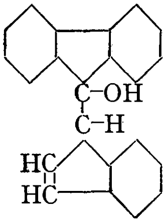
Grignard had an extremely systematic mind and his work in terpene chemistry led him to consider in detail the current nomenclature of organic compounds. His first publication on this subject was in 1910 and his appointment in 1912 as a member of the Commission of Organic Nomenclature was specially appropriate. Although he did not become a member of the Commission of the Union Internationale de Chimie after the War, his criticisms, published in 1927 and 1928, of the preliminary findings of the Commission were extremely logical and useful to the Commission.

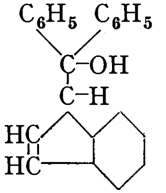
At about this time, Grignard devised his method for the more effective inter-condensation of aldehydes, by dissolving the aldehyde in a sufficient quantity of an appropriate solvent (generally ether) and allowing this to react at a suitable temperature with rapid stirring with an energetic condensing agent (alkali sulphite or alkali hydroxide) dissolved in a small quantity of water or other solvent only slightly miscible with the former. The successive ' aldolisation ' of small quantities of the aldehyde in the aqueous solution of the condensing agent and successive removal of the aldol from the aqueous solution by the ether not only gave increased yields of the aldols but reduced the formation of polymerised derivatives to a minimum.

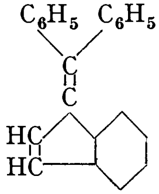
The numerous simple and mixed aldols so prepared were converted into the corresponding unsaturated aldehydes, which were then treated with organo-magnesians; similarly from these aldols, unsaturated and saturated alcohols were prepared and characterised. From the latter, Grignard prepared and studied in detail a number of new ethylenic hydrocarbons : from the former, he obtained a considerable number of complex hydrocarbons having two double bonds, whose derivatives were also investigated. The alcohols and their derivatives were similarly investigated, and the physical constants of all these related substances carefully determined. The determination of the molecular refractions of this series of compounds formed an important addition to our knowledge of the relationship between constitution and molecular refraction.

In 1909 Grignard was appointed to take charge of the department of organic chemistry at Nancy in succession to Blaise, who had been appointed to Paris on the death of Bouveault. In the following year, at the age of 40, Grignard became Professor of Organic Chemistry at Nancy, succeeding to a well-equipped department having a great reputation established by Haller and maintained by Bouveault and Blaise.

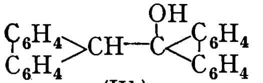
One of Grignard's most important investigations at Nancy, with Courtot as collaborator, had indene as its starting point. In view of the fact that indene forms a sodium derivative, Grignard concluded that it should also form a magnesium derivative and he prepared the sparingly soluble magnesium indenyl bromide,  $C_6H_4\left\langle\begin{array}{l}CH\\CHMgBr\end{array}\right\rangle CH$, by the action of organo-magnesium bromides on indene. By the usual methods, 1-indenol and indene-1-carboxylic acid were also isolated. By the action of magnesium indenyl bromide on fluorenone at 120° Grignard obtained *tert.*-1-indenylfluorenol (I). By a similar reaction

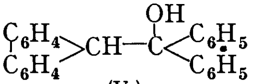

(I.)

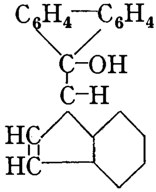

(II.)


(III.)

with benzophenone, he isolated 1-indenyldiphenylcarbinol (II), part of which suffered loss of water, producing the orange-coloured diphenylbenzfulvene (III). He extended this


$\left.\begin{array}{l}C_6H_4\\C_6H_4\end{array}\right\rangle CH-\overset{OH}{C}\left\langle\begin{array}{l}C_6H_4\\C_6H_4\end{array}\right.$
(IV.)


$\left.\begin{array}{l}C_6H_4\\C_6H_4\end{array}\right\rangle CH-\overset{OH}{C}\left\langle\begin{array}{l}C_6H_5\\C_6H_5\end{array}\right.$
(V.)


(VI.)

work to *cyclo*pentadiene and to fluorene, the magnesium derivative of the latter being prepared at 135° in xylene, and obtained derivatives of these hydrocarbons analogous to those of indene. He isolated, for example, *tert.*-fluorenylfluorenol (IV) and certain derivatives as well as fluorenyldiphenylcarbinol (V) and *tert.*-1-indenylfluorenol (VI). The preparation of the benzfulvenes and dibenzfulvenes by the dehydration of the above compounds as well as from the magnesium derivative of *cyclo*pentadiene followed naturally and made these compounds comparatively easy of access.

At the same time, Grignard and his pupils were occupied with the synthesis of cyanides by the action of organo-magnesians on gaseous cyanogen chloride and on cyanogen. In the former case, Grignard described the actions as follows :

$$\mathrm{RMgX + Cl{\cdot}C{\vdots}N \longrightarrow Cl{\cdot}CR{:}NMgX \longrightarrow RCN + MgXCl}$$

and in the latter case as

$$\mathrm{RMgX + (CN)_2 \longrightarrow N{\vdots}C{\cdot}CR{:}NMgX \longrightarrow RCN + NCMgX}$$

Grignard showed that cyanogen halides are capable of reacting not only as indicated above but also, particularly cyanogen bromide and iodide, thus :

$$\mathrm{XCN + MgRX' \longrightarrow RX + MgCNX'} \quad (\mathrm{X\ and\ X' = Br, I})$$

With cyanogen iodide this is the chief reaction; with cyanogen bromide, both reactions occur, although the latter predominates. This reaction for introducing bromine and iodine has proved useful in several instances for the preparation of halogen derivatives not otherwise easily accessible, as, for example, in the preparation of halogen derivatives of acetylenic hydrocarbons :

$$\mathrm{R{\cdot}C{\vdots}C{\cdot}MgBr + BrCN \longrightarrow R{\cdot}C{\vdots}CBr + MgBrCN}$$

An important extension of this investigation was the method of preparing ketones by acting with two molecular proportions of magnesium alkyl or aryl halide on one molecular proportion of cyanogen chloride, the reactions taking place being :

$$\mathrm{Cl{\cdot}C{\vdots}N + MgRX \longrightarrow Cl{-}\underset{R}{C}{:}N{\cdot}MgX}$$

$$\mathrm{Cl{\cdot}CR{:}NMgX \xrightarrow{MgRX} \genfrac{}{}{0pt}{}{R}{R}{>}C{:}NMgX + MgXCl}$$

$$\mathrm{\genfrac{}{}{0pt}{}{R}{R}{>}C{:}NMgX + H_2O \longrightarrow \genfrac{}{}{0pt}{}{R}{R}{>}C{:}NH + MgX{\cdot}OH}$$

$$\mathrm{\genfrac{}{}{0pt}{}{R}{R}{>}C{:}NH + H_2O \xrightarrow{acid} \genfrac{}{}{0pt}{}{R}{R}{>}CO + NH_3}$$

The Nobel Prize for Chemistry in 1912 was divided between Professor Paul Sabatier (also an Honorary Fellow of our Society) for his method of catalytic hydrogenation and Professor Victor Grignard for his discovery of the organo-magnesium compounds. Grignard received the award with becoming modesty and when he was being acclaimed by his colleagues and students at Nancy he said " La récompense suédoise aurait dû d'abord être décernée à Sabatier et Senderens, puis plus tard c'eût été mon tour de la partager avec Barbier." On this and many other occasions, Grignard was always ready to acknowledge his indebtedness to his 'maître vénéré,' and Barbier, pleased with the independent recognition of his pupil, said, " Grignard a rappelé la parte légitime qui lui revient dans une telle découverte. Mais le réactif préparé simplement comme nous venons de le décrire est de Grignard seul et c'est la découverte de ce réactif aux aptitudes réactionnelles infinies, que récompensait l'aréopage de Stockholm."

After the annual meeting in July, 1914, of the French Association for the Advancement of Science at Le Havre, in which Grignard had taken a prominent part, he went to Saint-Waast-la-Houge for his annual holiday; and it was there that Grignard was mobilised in his former rank of corporal, the rank which he had attained during his military service in 1893, becoming a coast-guard at Cherbourg before he was called to carry out chemical investigations of national importance. Grignard spent nearly a year investigating new or unexplored sources of toluene at Nancy and was then transferred to Paris to work in connexion with gas warfare in Urbain's laboratory at the Sorbonne. He investigated the preparation of phosgene by the action of oleum on carbon tetrachloride. The chlorosulphonic acid, a by-product in the reaction

$$H_2SO_4 + SO_3 + CCl_4 \longrightarrow COCl_2 + HClSO_3,$$

was converted into the ethyl ester by treatment with ethylene, and this ester proved to have lachrymatory properties. Grignard showed that the following reaction can be brought about at about 80° in the presence of certain catalysts and particularly by infusorial earth,

$$2H_2SO_4 + 3CCl_4 \longrightarrow 3COCl_2 + 4HCl + S_2O_5Cl_2$$

This rendered the use of oleum or sulphuric anhydride unnecessary for this method of producing phosgene. The pyrosulphuryl chloride was isolated as a chemical individual and, later, from its physical constants Grignard suggested that its constitution is $O{:}S(OCl){\cdot}O{\cdot}(OCl)S{:}O$.

Like many other workers at this time, Grignard studied the conditions for the chlorination of methyl formate and methyl chloroformate; he established the conditions for the production of mono-, di-, and tri-chloromethyl chloroformates and determined their physical constants.

Cyanogen bromide and iodide are useful lachrymators produced readily by the action

$$X_2 + MCN \longrightarrow XCN + MX \ (X = Br \text{ or } I,\ M = Na \text{ or } K)$$

but one half the bromine or iodine is ' lost ' for the immediate purpose. Grignard showed that, whereas chlorine liberates bromine and iodine from alkali salts, it does not react appreciably with cyanogen bromide and iodide at the ordinary temperature; by passing chlorine into the reaction mixture, the bromine or iodine liberated can then react with a fresh quantity of the alkali cyanide.

Grignard's test for ' yperite ' or mustard gas still remains the most convenient for field work. It consists in converting the compound into the more readily crystalline ββ'-di-iododiethyl sulphide by the reaction

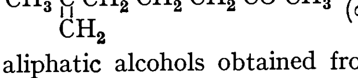
$$2NaI + (CH_2Cl{\cdot}CH_2)_2S \longrightarrow 2NaCl + (CH_2I{\cdot}CH_2)_2S$$

Using a simple apparatus, Grignard showed that it is possible to detect 0·01 gram of mustard gas in 1 cubic metre of air.

The French Academy of Sciences encouraged its members to continue the publication of their previous investigations in so far as their military duties permitted and at this time (1916) Grignard published an account of a method of obtaining mercurated aromatic alcohols, a class of compounds previously unknown. He showed, for example, that when ω-chloromercuriacetophenone reacts with ethyl magnesium bromide, the ketonic group is attacked, resulting in the production of α-chloromercuri-β-phenylbutan-β-ol, $CEtPh(OH){\cdot}CH_2{\cdot}HgCl$. Similarly, *o*-chloromercuribenzophenone gives α-phenyl-*o*-chloromercuriphenylpropan-α-ol, $CEtPh(OH){\cdot}C_6H_4{\cdot}HgCl$.

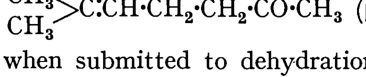
From August, 1917, until January, 1918, Grignard, now promoted to 2nd Lieutenant, was in America as representing Chemistry in M. Tardieu's " Mission d' Etudes." After demobilisation (February, 1919), Grignard returned to his professorship at Nancy, but in November of the same year he was appointed professor at Lyons in succession to Barbier, who had just retired under the age limit.

In continuation of his work on the dehydration of alcohols, Grignard investigated the cases of those obtained by the action of organo-magnesians on methylheptenone, which exists in two isomeric forms :



$$CH_3{\cdot}\underset{\overset{\|}{CH_2}}{C}{\cdot}CH_2{\cdot}CH_2{\cdot}CH_2{\cdot}CO{\cdot}CH_3$$

(α)

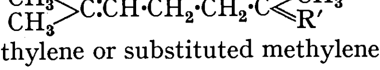


$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>C{:}CH{\cdot}CH_2{\cdot}CH_2{\cdot}CO{\cdot}CH_3$$

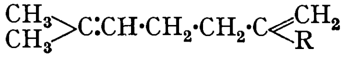
(β)

The aliphatic alcohols obtained from the β-form when submitted to dehydration with metaphosphoric acid yield dienes chiefly of the form (VII). The dienes derived from the

(VII.)



$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>C{:}CH{\cdot}CH_2{\cdot}CH_2{\cdot}C\!<\!\begin{matrix}CH_3\\R'\end{matrix}$$



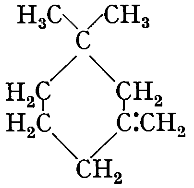
$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>C{:}CH{\cdot}CH_2{\cdot}CH_2{\cdot}C\!<\!\begin{matrix}CH_2\\R\end{matrix}$$

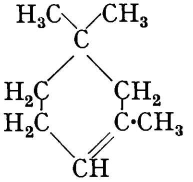
(VIII.)

(R' = methylene or substituted methylene)

aromatic alcohols (R = Ph or Bz) on the other hand have the constitution (VIII). When anhydrous oxalic acid is used as the dehydrating agent, the lower members of the aliphatic series yield $\gamma$- and $\alpha$-*cyclo*geraniolenes, (I) and (II) respectively, the latter being present in variable proportions and in less quantity.

(I.)





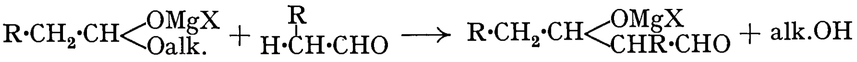
(II.)

Many years previously, Grignard had observed that, when *iso*amyl magnesium bromide reacts on acetone, small quantities of mesityl oxide and phorone are produced, and similar observations are recorded by other investigators. Subsequently, Grignard showed that condensation of aldehydes and ketones between themselves took place during the Grignard reaction, yielding unsaturated ketones. He correlated this type of condensation with what he described as the Cannizzaro–Tistchenko condensation, described for the first time by Franke and Kuhn in the case of $\alpha$-methyl-$\alpha$-hydroxymethylpropaldehyde (formyl-*iso*butyl alcohol)

$$2\mathrm{HO\cdot CH_2\cdot CMe_2\cdot CHO} \longrightarrow \mathrm{HO\cdot CH_2\cdot CMe_2\cdot CO\cdot O\cdot CH_2\cdot CMe_2\cdot CH_2\cdot OH}$$

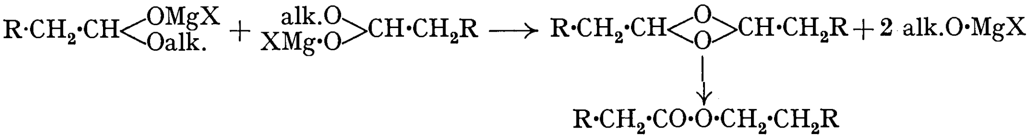
hydroxypivalyl hydroxypivalate

Grignard suggested that such condensations occurring under the influence of aluminium and magnesium alcoholates might be induced by magnesium halogen alcoholates, Mg(OR)X, which are normal products of the Grignard reaction. He showed that in ethereal solution these mixed alcoholates exhibit towards aldehydes and ketones much greater condensing powers than the ordinary alcoholates. They are capable, for example, of condensing ketones of which both radicals contain more than one carbon atom, such as diethyl ketone and dipropyl ketone; the condensing power increases from chlorine to iodine and is greater when tertiary radicals are present than for primary and secondary. Grignard's suggested mechanism of the condensation is: (1) addition of the alcoholate to the aldehyde or ketone, and (2) reaction of this complex with another molecule of the aldehyde or ketone:



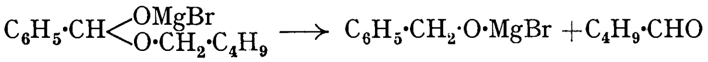
$$\mathrm{R\cdot CH_2\cdot CH}{<}\begin{matrix}\mathrm{OMgX}\\ \mathrm{Oalk.}\end{matrix} + \mathrm{H\cdot}\overset{\mathrm{R}}{\mathrm{C}}\mathrm{H\cdot CHO} \longrightarrow \mathrm{R\cdot CH_2\cdot CH}{<}\begin{matrix}\mathrm{OMgX}\\ \mathrm{CHR\cdot CHO}\end{matrix} + \mathrm{alk.OH}$$

He suggested that ester production took place *via* the ' hemiacetal,'



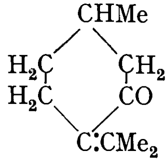
$$\begin{array}{l}\mathrm{R\cdot CH_2\cdot CH}{<}\begin{matrix}\mathrm{OMgX}\\ \mathrm{Oalk.}\end{matrix} + \begin{matrix}\mathrm{alk.O}\\ \mathrm{XMg\cdot O}\end{matrix}{>}\mathrm{CH\cdot CH_2R} \longrightarrow \mathrm{R\cdot CH_2\cdot CH}{<}\begin{matrix}\mathrm{O}\\ \mathrm{O}\end{matrix}{>}\mathrm{CH\cdot CH_2R} + 2\ \mathrm{alk.O\cdot MgX}\\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\downarrow\\ \qquad\qquad\qquad\qquad\qquad\qquad\qquad\mathrm{R\cdot CH_2\cdot CO\cdot O\cdot CH_2\cdot CH_2R}\end{array}$$

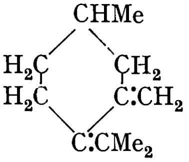
The reducing action of organo-magnesians has been observed by many workers, and Grignard's explanation of the formation of benzyl alcohol together with *iso*amylphenylcarbinol by the action of *iso*amyl magnesium bromide on benzaldehyde in breaking down the hemiacetal is:

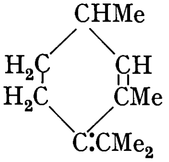


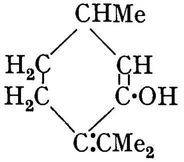
$$\mathrm{C_6H_5\cdot CH}{<}\begin{matrix}\mathrm{OMgBr}\\ \mathrm{O\cdot CH_2\cdot C_4H_9}\end{matrix} \longrightarrow \mathrm{C_6H_5\cdot CH_2\cdot O\cdot MgBr} + \mathrm{C_4H_9\cdot CHO}$$

Two of Grignard's important contributions to terpene chemistry were in connexion with pulegone and citronellol. By the action of methyl magnesium iodide on pulegone (I) he obtained a hydrocarbon to which he assigned constitution (II). Subsequent work has shown that this hydrocarbon is not homogeneous but probably a mixture of (II) and (III). In further work, Grignard showed that the volume of gaseous hydrocarbon evolved increased with increasing weight of the alkyl group (in the alkyl magnesium halide) and with that of the halogen; he showed further that the oil recovered from the reaction is not pulegone but its enolic form, pulegenol (IV), which he characterised as its benzoyl derivative. The fixation of the enolic form is due to the formation of a magnesium organo-enolate, a corresponding volume of gaseous hydrocarbon being liberated.

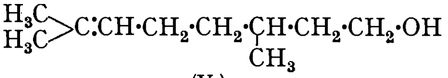

(I.)


(II.)


(III.)

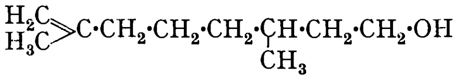

(IV.)

Grignard and his pupils made a notable contribution to chemistry in resolving the citronellol–rhodinol question. *d*-Citronellol was prepared in three ways: (i) from Java citronella oil, (ii) by the reduction of *d*-citronellal, and (iii) by the reduction of the acetyl derivative of the enolic form of *d*-citronellal. The material from each source was submitted to the action of ozone. Each specimen was found to be a mixture of the two alcohols (V) and (VI). The percentage composition of the mixtures determined from the amounts



$$(H_3C)_2C{:}CH{\cdot}CH_2{\cdot}CH_2{\cdot}CH(CH_3){\cdot}CH_2{\cdot}CH_2{\cdot}OH$$

(V.)



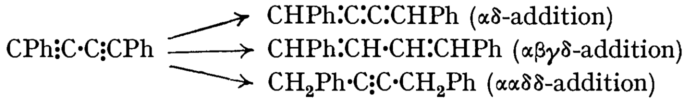
$$H_2C{:}C(CH_3){\cdot}CH_2{\cdot}CH_2{\cdot}CH_2{\cdot}CH(CH_3){\cdot}CH_2{\cdot}CH_2{\cdot}OH$$

(VI.)

of acetone and formaldehyde formed was between 76 and 81% of (V) and between 24 and 18% of (VI). *dl*-Citronellol synthesised from methylheptenyl bromide gave similar results on ozonolysis. They then prepared rhodinol by standard methods and showed that it had similar physical properties and the same chemical properties as citronellol and gave the same results on ozonolysis. Grignard's investigations in this field were carried out with the utmost care and left no doubt that citronellol and rhodinol are identical, both being mixtures of the two alcohols (V) and (VI).

The versatility of Grignard as a chemist is well illustrated by his investigations of catalytic dehydration and reduction at pressures lower than that of the atmosphere and at various temperatures, which resulted in different products according to the pressure and temperature at which the particular process was carried out. Thus, he obtained a yield of 67% of benzyl alcohol by reducing benzaldehyde at 150° and 100 mm., the unchanged aldehyde being recovered. By lowering the temperatures and pressure and using nickel as a catalyst, he was able to increase the proportion of the enolic form of benzylideneacetone, showing that 1 : 4 addition proceeds simultaneously with that normally taking place at the ketonic double bond. In the case of the reduction of phenol in *cyclo*hexanol solution, Grignard was able to isolate tetrahydrophenol, $CH_2{<}\begin{smallmatrix}CH_2{\cdot}CH_2\\CH_2{-}CH\end{smallmatrix}{\geqslant}C{\cdot}OH$, which apparently constitutes the first phase of the hydrogenation; the enolic form of *cyclo*hexanone later may become ketonic or be further reduced to the cyclic secondary alcohol. Grignard also obtained the enolic forms of 4-methyl*cyclo*hexanone and carvomenthone. Using platinum oxide as a catalyst at about 200° and at pressures varying from 140 to 400 mm., he showed that benzoyl chloride, phenylacetyl chloride and phenylpropionyl chloride were hydrogenated to the corresponding aldehydes without any appreciable formation of the by-products always produced at ordinary pressure. Unfortunately by this method only poor yields of the corresponding aldehydes are obtained from aliphatic acid chlorides.

Unsaturated hydrocarbons of various types and their derivatives provided a fruitful field of investigation for Grignard and his pupils for many years. From acetylenic magnesium halides of the type $R{\cdot}C{⋮}C{\cdot}MgX$, Grignard prepared a series of conjugated diacetylenes by the action of two atomic proportions of iodine on two molecular proportions of the reagent. He thereby obtained $\Delta^{\delta\xi}$-decadi-inene, $\Delta^{\epsilon\eta}$-dodecadi-inene, $\Delta^{\xi\theta}$-tetradecadi-inene, and αδ-diphenyldiacetylene. The last compound when submitted to catalytic hydrogenation gave three compounds, thus,



$$CPh{⋮}C{\cdot}C{⋮}CPh \longrightarrow CHPh{:}C{:}C{:}CHPh \text{ (αδ-addition)}$$

$$CPh{⋮}C{\cdot}C{⋮}CPh \longrightarrow CHPh{:}CH{\cdot}CH{:}CHPh \text{ (αβγδ-addition)}$$

$$CPh{⋮}C{\cdot}C{⋮}CPh \longrightarrow CH_2Ph{\cdot}C{⋮}C{\cdot}CH_2Ph \text{ (ααδδ-addition)}$$

Since the days of Sir Edward Frankland, the preparation and investigation of organometallic compounds have been carried out by many workers chiefly for the purpose of solving problems in valency and stereochemistry. These compounds were first prepared by the action of the zinc alkyls and later by means of the organo-magnesians. It is somewhat interesting that this type of investigation did not greatly appeal to Grignard himself; his only excursion into this field resulted in the preparation of aluminium diethyl iodide and aluminium ethyl di-iodide. He found that these compounds are of little use under such conditions as the Friedel–Crafts reaction and they do not react with carbon dioxide or, in general, like the organo-magnesians.

Grignard had for long contemplated the production of a comprehensive treatise in French on Organic Chemistry, a project which Moureu had previously had in view, and at length announced the publication of a "Traité de Chimie organique" in fifteen small quarto volumes. The first volume appeared in 1935 and four volumes, all edited by Grignard, have already been published. There is reason to believe that the labour involved in this work was too great a tax on the strength of one already overworked.

Many honours came to Grignard and were accepted with a quiet dignity which was characteristic. He was a Commander of the Légion d'Honneur and became member of the Académie des Sciences in 1926. He was an honorary member of the Chemical Societies of England, France, America, Belgium, Roumania and Poland, and of the French Society of Chemical Industry, an honorary member of the Royal Society of Sciences of Upsala, and Roumania, a corresponding member of the Polish and Roumanian Academies, and held the Doctorate, *honoris causa*, of the Universities of Brussels and Louvain.

With the exception of one year at Besançon and about four years as Professor at Nancy, the whole of Grignard's academic life was spent in the University of Lyons. The spirit of centralisation is strong in France and is well expressed by Pasteur's pronouncement on a promising young man—"Ce jeune homme se placera rapidement au nombre de nos mathématiciens les plus éminents. Il faut absolument qu'il reste à Paris." In spite of the lustre attaching to an office in the capital Grignard refused at least two requests to accept a professorial chair in Paris. Although a man of great personal charm and force of character, he feared that absorption by administrative duties which always await competent scientific workers in the metropolis. With that modesty which was recognised by all who knew him, Grignard preferred the academic quiet of Lyons, and the opportunity it provided for the undisturbed continuance of his research work. He died on December 13th, 1935, and was buried at Lyons. His pupil, collaborator and friend, Professor Ch. Courtot, has recently published a comprehensive account of his work in the *Bulletin de la Société chimique de France.**

C. S. Gibson.
W. J. Pope.

## JAMES FRANCIS HALPIN.

1866—1936.

James F. Halpin was born at Limerick on August 3rd, 1866. He was educated at Camelford School, Cornwall, and studied chemistry at King's College and the Royal College of Science, London.

After some experience with the Excise Department Halpin was appointed in 1892 to the Government Laboratory, then occupying a part of Somerset House. In this department Halpin spent the major part of his official career, and retired with the rank of Superintending Chemist in 1929.

His work in the Government Laboratory was concerned chiefly with the chemical control of the Customs and Excise duties on beer, sugar, wine and spirits, and investigations in connexion therewith. In the course of his work he acquired an exceptional knowledge of

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* In the photograph accompanying this notice, Grignard is standing in his laboratory at Lyons before his apparatus for carrying out hydrogenations under reduced pressures at the same place where he first prepared the Grignard reagent.

Revenue questions, and his special experience was utilised on a number of Departmental committees to which he was appointed.

In addition to the chemical side, Halpin possessed an intimate knowledge of the historical, legal, and administrative aspects associated with Customs and Excise duties and he never wearied of imparting valuable information and advice on questions pertaining to the Revenue to his staff and colleagues.

When he retired from the Government Chemist's Department he was awarded the Imperial Service Order.

Halpin was always energetic and it was not surprising, therefore, that within a year of his retiral from the Government Laboratory he re-entered active employment when he became Director of the Egyptian Government's Tobacco Laboratory at Cairo. He served in that capacity for four years, finally returning to England in 1934. He died after a short illness on June 21st, 1936.

In his spare time Halpin was an omnivorous reader. He enjoyed long tramps in the countryside and was an enthusiastic observer of bird life. He had a quiet unassuming manner and an even-tempered and courteous disposition. His relations with his staff and colleagues were ideal and he was greatly missed when he left the Government Laboratory.

Halpin was a Fellow of the Chemical Society and of the Institute of Chemistry. He is survived by his widow, one son, and a daughter.

A. J. H. GAUGE.

## HENRY REGINALD HIRST.

1876—1936.

HENRY REGINALD HIRST was born at Batley in 1876, the eldest son of the late Mr. G. H. Hirst, owner of the well-known woollen mills which still run under the title G. H. Hirst & Co., Ltd.

Hirst received his early education at the Wheelwright Grammar School, Dewsbury, and proceeded to the University of Leeds, where he graduated B.Sc., Honours in Chemistry, in 1905; he received the degree of M.Sc. in 1929. He was a Fellow of the Chemical Society, a Fellow of the Institute of Chemistry, a member of the Institute of Chemical Engineers, a member of the Society of Dyers and Colourists, and a member of Committee of the Bradford Textile Society.

On leaving the University Hirst entered the family business and here laid the foundations of his wide knowledge of technical processes in the woollen industry. Despite the fact that during the war his firm were busily employed on army clothing contracts, he was anxious to take a more active part and joined the forces in 1915. After a period of general training he was transferred to the ordnance inspection depot near Rouen, where he was responsible for the examination of all types of ammunition passing through the centre. He received official recognition for "Coolness and gallant conduct at an ammunition base on July 3rd, 1917, in helping to put out a fire on board an ammunition ship."

In 1920 Hirst joined the newly formed British Research Association for the Woollen and Worsted Industries, now the Wool Industries Research Association, and at the time of his death was its chief Technologist. Although apparently in excellent health, he had a sudden heart attack and died at his home on December 10th, 1936.

Hirst evinced an especial interest in finishing processes, and for research on such processes his experience gained in industry was most valuable. His interest in milling processes caused him to carry out fundamental work on the swelling of wool fibres when placed in various solutions, and more technical researches dealt with methods for increasing the rate of milling by suitable pre-treatment of the cloth, thus effecting a saving in time and enabling production to be increased. Much of his work concerned the elucidation of the causes of defects in materials, and in this work his interest did not cease with the resolution of a particular problem, but he was at all times keenly alive to the desirability of devising methods for the prevention of such defects. He was a pioneer in the study of the causes and prevention of mildew and worked out satisfactory methods for its prevention and made clear the conditions under which wool is liable to mildew attack. Perhaps his greatest interest was in dyeing processes and related problems. In 1925 he suggested a general scheme of test to be applied in the determination of fastness of dyes to wool to various agencies, *e.g.*, light, washing, perspiration, stoving, etc. He was a member of the Committee of the Society of Dyers and Colourists which in later years initiated and carried out comprehensive investigations on standard methods of test for fastness to light, washing, and perspiration for all types of coloured textile materials.

The demands of his work led Hirst to develop new analytical methods and he was ever ready to take advantage of advances in other branches of science and apply them to his own particular problems. An outstanding example of this is the great use he made of ultraviolet radiation as an aid in textile analysis, especially in the examination of oil stains. He was greatly interested in photography both as a hobby and as an aid in his work, and at the time of his death was developing the methods of fluorescence photography for the examination of defects caused by oil stains.

Although keenly alive to the general problems of the day, Hirst evinced little interest in politics until recent years, when he became a keen supporter of the Social Credit Party. Many of his spare evenings were spent in attending and giving lectures on this subject. His leisure was spent in the country, where he had a small estate and took much delight in the growing of choice fruits.

His death, though tragic in its suddenness, may also be regarded from the point of view of a classical authority who said many centuries ago " It is a sign of a fortunate man to die before he calls on death."

W. I. R. A.

## JAMES HENRY HOSEASON.

1869—1936.

JAMES HENRY HOSEASON, who died on September 22nd, 1936, at his home, St. Michael's Mount, Hankham, Sussex, aged sixty-seven years, was born at Chefoo, China, on February 18th, 1869. His father, a native of the Shetland Islands, was a captain in the Mercantile Marine and incidentally was able to teach his son Greek. Hoseason was educated in Edinburgh, served an apprenticeship to pharmacy in that city, and had further experience under John B. Stephenson, Chairman of the Board of Examiners (Scotland) of the Pharmaceutical Society. He received his scientific training at the Heriot-Watt College, Edinburgh, during the professorships there of W. H. Perkin, jnr., and F. Stanley Kipping. Having obtained the qualification of pharmaceutical chemist, he was appointed, in 1891, Assistant Lecturer in Materia Medica, Pharmacy and Pharmaceutical Chemistry, under Professor D. J. Leech, M.D., at Owens College, Victoria University, Manchester, with entire charge of the Pharmaceutical Department. Resigning this appointment in 1896, he entered upon a commercial career and in 1900 became partner and works manager in the firm of Hough, Hoseason & Co., manufacturing chemists, Manchester, and remained there until his retirement some twelve years ago. He did a large amount of research work on digitalis and on the production of artificial shellac. This he made in limited quantities, founding the Anglo-Indian Manufacturing Co., but the venture was abandoned after five years' existence. He also published various papers and notes on pharmaceutical subjects from the year 1889 on. He was elected a Fellow of the Chemical Society on February 18th, 1909, and his interest in scientific matters remained unabated after his retirement.

JAMES GRIER.

## EMANUELE PATERNÒ.

1847—1935.

EMANUELE PATERNÒ DI SESSA, the bearer of an old Sicilian family name, was born in Palermo on December 12th, 1847, shortly before his father, who was implicated in the revolution of 1848, was exiled and left, with his wife and family, for Egypt. After the death of the father at Alexandria in 1858, the mother settled in Genoa with her sons, not caring to return to Sicily under the domination of the Bourbons. The family returned to Palermo in 1860 and in due course young Paternò commenced his higher education under Naquet, then Professor of Chemistry at the Technical College. He worked later under Cannizzaro at the University of Palermo and took his Doctorate in Physics and Chemistry in 1871.

Lieben, who was Assistant Director of Cannizzaro's Laboratory at Palermo from 1863 to 1867, had done much to explain the production of chloral from alcohol and chlorine and Paternò's first original work was devoted to the detailed study of the reactions concerned. He thus isolated trichloroacetal, prepared dichloroacetaldehyde from the corresponding acetal, and obtained pure pentachloroethane by treating chloral with phosphorus pentachloride in 1869; a little later he obtained tetrachloroethylidene dibromide by the action of bromine on pentachloroethane and prepared several other highly chlorinated and brominated methanes and ethanes. He did not confine himself to problems related to chloral but at the same time studied the formation of phenylpropiolic acid from phenylacetylene and worked with Koerner on the sulphonation of iodobenzene and with Amato on the synthesis of crotonaldehyde from acetaldehyde and ethylidene chloride.

In 1875 Paternò noted that 3-nitrocuminic acid was converted into a red amorphous product by sunlight and he continued the study of the chemical action of light for many years. Thus he demonstrated the formation of propyl butyrate by the action of light on butyric acid and carried out a number of other interesting photo-syntheses, some of which may be reproductions of actual plant syntheses. Among the condensations thus effected may be mentioned the production of $\alpha\beta\beta$-triphenylhydracrylic acid,

$$(C_6H_5)_2C(OH)\cdot CH(C_6H_5)\cdot CO_2H,$$

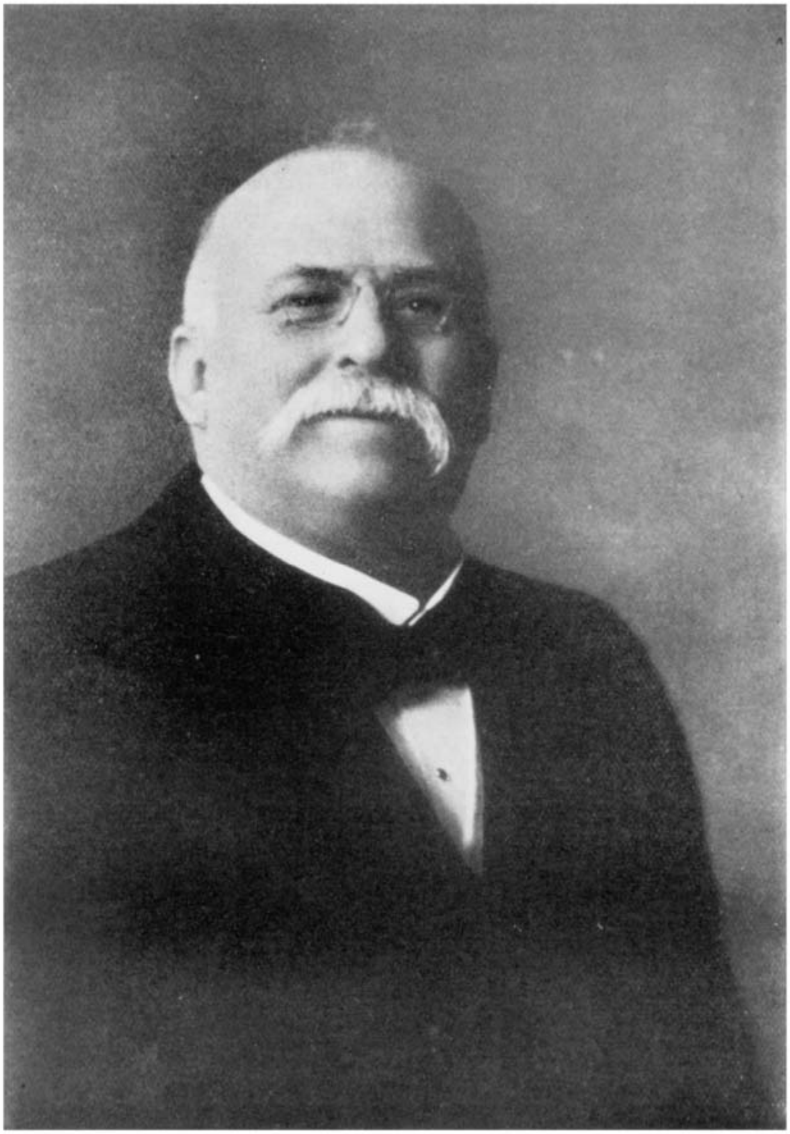
by the action of sunlight on benzophenone and phenylacetic acid in benzene solution.

At the time when Paternò was interesting himself in the halogen derivatives of the simple paraffins two modifications of ethylene dichloride were supposed to exist; to explain this he introduced in 1869 the conception of the tetrahedral configuration of methane and published diagrams indicating the conceivability of a kind of *cis*- and *trans*-isomerism of ethylene dichloride, without postulating, of course, free rotation of the carbon atoms. Some controversy has arisen in later days on the question as to whether Paternò should receive priority over van 't Hoff and Le Bel in connection with the conception of the asymmetric carbon atom. The idea that a quadrivalent atom is tetrahedrally environed dates at least from Wollaston in 1808 and Paternò claimed no credit in this connection; the notion of asymmetry as applied to the optical activity of methane derivatives dates from the publications of van 't Hoff and Le Bel in 1874. It is interesting, however, to note that Debye was endeavouring in 1930 to obtain evidence by *X*-ray analysis of the existence in gaseous ethylene dichloride of two isomerides corresponding in configuration to the isomerides foreshadowed by Paternò more than sixty years before.

In 1870 Paternò published a short paper in the *Gazzetta* showing that carbonyl chloride is formed readily by the catalytic action of animal charcoal on a mixture of carbon monoxide and chlorine. This reaction is interesting, first because it is probably the earliest example of the use of carbon as a catalyst, and, secondly because most samples of animal charcoal have no catalytic action on the mixed gases. For long after Paternò's publication phosgene was manufactured for technical purposes by exposing carbon monoxide with chlorine to sunlight in glass carboys; it was ultimately found, however, that properly prepared charcoal catalyses the reaction with great rapidity and Paternò's method is now used exclusively for the technical manufacture of phosgene.

Paternò was greatly interested in natural products; he carried out an extensive investigation of cymene from various sources, and studied such components of lichens as usnic acid. His work on lapachic acid or lapachol, published in 1882, is monumental and established that this substance is a derivative of $\alpha$-naphthaquinone. He interested himself in organic fluorine compounds and, in collaboration with Olivieri, was the first to prepare fluorobenzene; these co-workers characterised the three fluorobenzoic acids in 1882.

Paternò was one of the first to be attracted by the work of Raoult on the depression



Emanuele Paternò

[*To face p.* 182.

of the freezing point of solvents by solutes and its bearing on the determination of molecular weights. In conjunction with Nasini he showed that citraconic, itaconic and mesaconic acids have the same molecular formula and hence are not related as polymerides. They showed that bromine has the composition $Br_2$ in aqueous solution and that in benzene sulphur has the molecular composition $S_6$. He did a good deal of work on colloidal solutions and was the first to advance the view, in 1889, that such substances as gallic and tannic acids exist in aqueous media as suspensions of swollen particles which are still sufficiently small to pass through filter paper.

In 1871, when only twenty-four years of age, Paternò started the *Gazzetta di Chimica Italiana* and, fifty years later, when handing the journal over to the Associazione Italiana di Chimica Generale ed Applicata, he reprinted in the *Gazzetta* all his early papers which had appeared in the *Giornale di Scienze Naturali ed Economiche di Palermo*, so that, as he said, all his contributions to Chemistry should appear in the same journal. In the preface to volume 50 of the *Gazzetta*, in relinquishing the Editorship, he recounted the early financial difficulties of the publication and tells how Cannizzaro, who was joint Editor with himself, foreboding failure, insisted on the journal appearing anonymously. In an earlier issue, that of January, 1883, Paternò gave a description of the teaching and research work done in the Chemical Laboratory of the University of Palermo during his tenure of office—from 1872—and describes how an unsuitable building had been made to serve and a poor financial subvention had been applied, as he said—" e Dio sa come," yielding results of which he was justifiably proud. He noted that the laboratory subvention amounted to about £300 per annum but its old students, Fileti, Ogilaloro, Spica and Mazzara, trained under him, had all been appointed to professorial chairs. In 1923 the Associazione Italiana di Chimica established a gold medal in honour of Paternò to be awarded trienially for the most important piece of chemical work done during the preceding ten years; the first recipient of the medal was F. W. Aston of Cambridge.

Paternò became Professor of Chemistry in the University of Palermo when Cannizzaro was appointed to the Chair at Rome in 1872. He went to Rome as Professor of Applied Chemistry in 1893 and, on Cannizzaro's death in 1910, was elected Professor of General Chemistry and Director of the Chemical Institute in the University; he retired from teaching work in 1923 at the age of 75 as Emeritus Professor. Throughout his active life Paternò filled many municipal and government offices; he had been Rector of the University of Palermo and became a Senator of the Kingdom in 1890, serving for many years as Vice-President of the Italian Senate. He received the honorary Sc.D. of the University of Cambridge in 1912 and was elected an honorary Fellow of the Chemical Society in 1920; he became a National member of the Accademia dei Lincei in 1883 and a Foreign Associate of the Académie des Sciences in 1923. He died in Palermo on January 18th, 1935.

Paternò was a thick-set sturdy figure full of energy and vivacity. Although his interests in chemical science and technology were wide, as is shown by his publications, he had a vast knowledge of world affairs, stimulated no doubt by the political turbulence amid which his early days were spent. He was a charming personality, a lively and humorous conversationalist, and a delightful companion even to those much younger than himself.

W. J. POPE.

## WILLIAM RINTOUL.*

1870—1936.

WILLIAM RINTOUL died at the age of sixty-six years at his home in Ardrossan, Ayrshire, on August 25, after nearly a year's illness. His career had been a remarkable one, and began in Glasgow, where he was educated and received in Glasgow and West of Scotland Technical College his scientific training. In the late 'eighties there were (as there are even now) few schools of analytical chemistry, so that Mr. R. R. Tatlock not only filled the post of city analyst but also himself lectured and had a staff of lecturers on chemistry and

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physics to students many of whom afterwards became his assistants and later occupied important positions in the chemical profession. Ramsay was one of them.

After a short time as an assistant, Rintoul lectured to Tatlock's students until in 1891 a post of chemist offered in a paint manufacturer's near London, where he got chemical and works experience. After three years there he went in 1894 to the Royal Gunpowder Factory as a chemist in the laboratory, later becoming chemist-in-charge of the manufacture of nitroglycerine, and for two years before he resigned he was chief chemist in the laboratory.

At this time the Royal Gunpowder Factory under Sir Frederic Nathan as superintendent and Mr. James Thomson as manager led the explosives industry in Great Britain in organization, in safety precautions and in the invention of new processes and plant. Rintoul, naturally inventive and of remarkable manual skill, did his full share, of which the displacement process for the manufacture of nitroglycerine is an example. This process improved the manufacture of that explosive economically in that no high buildings were required to house the plant and also from the point of view of safety, as the nitroglycerine was removed (by upward displacement) from its acid mixture as soon as it had been formed and was sent at once for its preliminary washing, instead of being left to separate in bulk in an acid, and more or less dangerous, state. At this time also he was co-inventor with Robertson of a process and plant for the recovery of acetone, the solvent used in the manufacture of cordite.

Accompanying Sir Frederic Nathan to Nobel's Explosives Company (now part of Imperial Chemical Industries, Ltd.) at Ardeer in Ayrshire in 1909 as chief chemist, he became research manager there and devoted himself to the organization of the laboratories and erection of many new ones. His policy had several features which have been commended by others in like position, as for example, the provision that all chemists, whether destined for research or plant, should first undergo a thorough training in analytical chemical methods, the insistence on a good system of documentation of reports and of published work, the installation of physical methods of testing explosives and close contact with the universities. While at Ardeer he was associated with a number of patents chiefly on stabilizers for explosives, and developed a keen interest in biochemical investigations, some of which are described (with Raistrick) in the *Philosophical Transactions of the Royal Society*.

About ten years ago Rintoul was brought up to the headquarters of Imperial Chemical Industries, Ltd., as a director of its research organization, from which he maintained an active and sympathetic contact with all the company's laboratories, and came into close touch with many prominent scientific men who were working directly or indirectly in the company's interests, for it was part of his duty to administer the support given by the company to wide-spread scientific activities. In these matters he gained the respect and affection of everyone with whom he came in contact, and as representative of his firm was well known abroad, where he attended many conferences.

Rintoul was made an O.B.E. for his work in the Great War, and assisted on many committees such as the Councils of the Chemical Society and Institute of Chemistry, the Safety in Mines Research Board, the Chemistry Research Board (D.S.I.R.), the Research Committee of the Midland Railway and the British Standards Institution. When he died he was president of the Faraday Society, in the discussions of which he took much interest.

Rintoul married twice : first Lottie Edwards, by whom he had two sons and a daughter, and secondly, two years ago, Jess Isabel Robertson. (Sir) R. ROBERTSON.

## ALTON EWART CLARENCE SMITH.

1887—1936.

A. E. CLARENCE SMITH was born on March 20th, 1887, at Chislehurst, a son of Sir Clarence Smith, J.P., D.L., of Wilmington Manor, Dartford. He was educated at the Leys School and at Christ's College, Cambridge. After taking first classes in the Natural Sciences

Tripos, Part I in 1908 and Part II in 1910, he returned to the University to undertake research but had to abandon this owing to ill-health. Some time later he went as a student to the Marine Biological Station at Plymouth and his interest in microscopy dates from this period. At the outbreak of war he volunteered for military service, and was given a commission in the 13th South Lancashire Regiment in September, 1914. He was gazetted Captain in 1915, but after active service in France was invalided out in 1917 with acute gastritis. He afterwards returned to work with the Effandum Company at Wolverhampton, where prior to the war he had been employed as research chemist, and where munitions of war were now being manufactured.

In 1919 he was appointed Lecturer in Physical Chemistry at University College, Southampton, a position which he occupied until his death on September 16th, 1936. At the time of his appointment the University College had just moved into its new buildings at Highfield and the planning and equipment of a laboratory for Physical Chemistry was one of his earliest tasks. At first use had to be made of one of the Army huts erected during the occupation of the College buildings as a Military Hospital, and in the transformation of this unpromising building into a laboratory for Physical Chemistry Clarence Smith showed characteristic ingenuity. Some years later a more suitable building became available and the fitting up of this as a Physico-chemical Laboratory again gave scope for his originality and mechanical skill as well as his scientific knowledge. His own research work was devoted chiefly to studies in connection with photomicrography; his publications in the *Journal* of the Photo-micrographical Society, the *Journal* of the Quekett Club and similar periodicals had given him a recognised position as a leading expert in this subject. He had recently been awarded the medal of the Royal Photographic Society and, in the opinion of one very competent judge, he was without exception the most accomplished technician in photomicrography in this country. But Clarence Smith was in the first instance a teacher. His main efforts were devoted to the building up of his young and growing department of Physical Chemistry and to maintaining the teaching of his subject at the highest possible degree of efficiency. For this task he was especially fitted by tastes and natural endowments. He had a remarkable gift for accurate speech and writing and a corresponding dislike for careless and inexact phrasing. He had read widely and always with a critical mind. He took very great pains in the preparation of his lectures, and these were extraordinarily clear and effective. He was very happy in his relations with his students, who had a warm affection and respect for him. They knew that he always gave them of his best and that he would grudge no expenditure of time or trouble to help them. By his colleagues on the staff of the University College he was held in peculiar esteem as a man obviously free from all petty jealousies and whole-heartedly working for the common good. His tact and judgment, combined as they were with an unfailing courtesy, often proved decisive factors in achieving a happy solution where difficult academic problems were involved. He was always ready to place his scientific knowledge and experience at the service of his colleagues, his wide scientific interests (which included zoology as well as physics) making it possible for him to give helpful advice in more than one branch of study.

The research work in chemistry at Southampton during the past seventeen years owes a very special debt of gratitude for his ready interest and generous help. Another aspect of Clarence Smith's contribution to the development of the University College deserves mention. He acted for a number of years as secretary to the Faculty of Science and in this capacity showed gifts of organisation of a very remarkable kind. In this work, as in everything else which he undertook, he never spared himself. His death, which occurred with tragic suddenness as the result of an illness contracted while he was enjoying one of his favourite holidays on the Broads, has deprived University College, Southampton, of one of its most able teachers and one whose personal influence was felt and greatly valued in many different phases of College life. He married in 1916 Hilda Burnet, daughter of Mr. Theodore E. Salvesen, of Carbisdale Castle, Culrain, and is survived by his wife and four children.

D. R. Boyd.

## SIR RICHARD THRELFALL, G.B.E., F.R.S.

1861—1932.

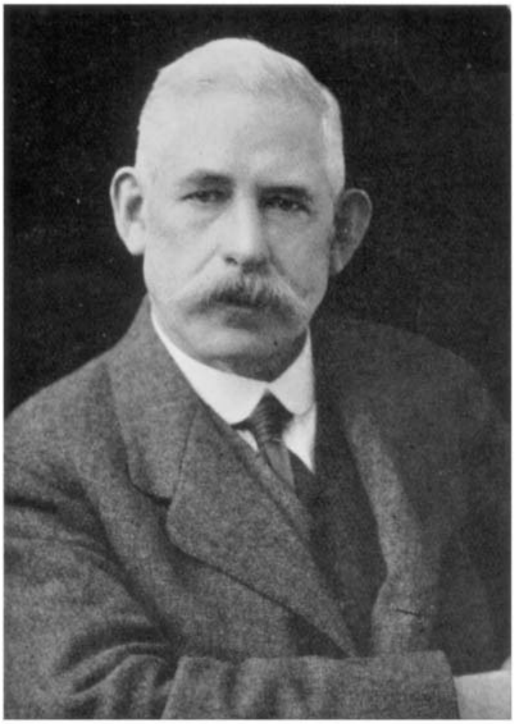
FIFTY years ago when Threlfall was twenty-five there must have been few scientists in England who had never heard of him: to-day it is possible that the majority of Fellows of the Chemical Society know little about him. Yet he was one of the great men of his age: great in achievement, in character, and in his power to stimulate others to produce the best that was in them. His best work was, and still is, confidential in nature; and most of his published scientific work, although it shows ample evidence of his experimental skill, has left little obvious mark on the progress of Science. It is all the more necessary, therefore, in this short memoir, to try to preserve a true impression of a man who had an outstanding reputation among his contemporaries.

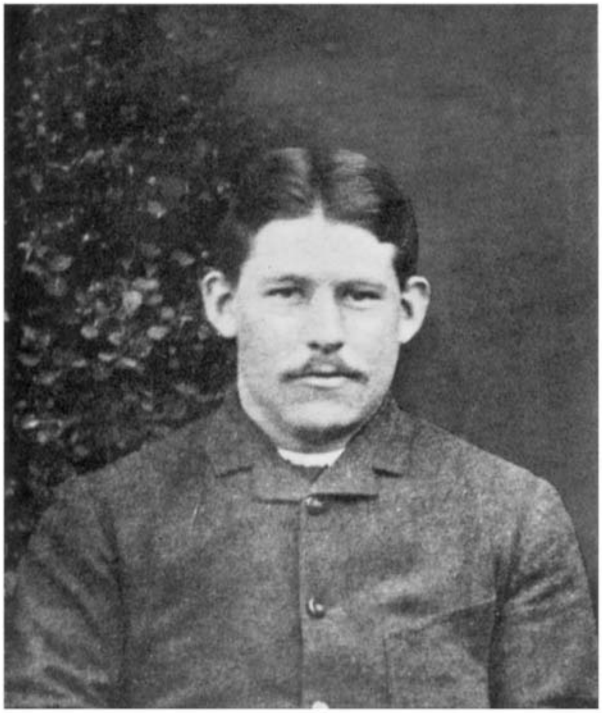
Richard Threlfall was born on August 14th, 1861, at "Hollowforth", in the village of Woodplumpton near Preston. His father had been in business in Preston as a wine merchant and was Mayor of Preston in 1855—56. His mother was his father's second wife; she had six children, two of whom died in childhood, leaving Richard the eldest. He had two brothers, one an able botanist, who was drowned near Baghdad on a botanical expedition, and the other an engineer, who also died abroad. His sister, Mrs. Ascroft, survives him.

Threlfall had few memories of his father, who died in 1870. A year before his death, he was asked by his son to help him to make a galvanic battery, but did not rise to the occasion. This lack of parental encouragement seems to have stimulated rather than deterred the boy, and from that time on Richard Threlfall taught himself to be an experimenter. While he was still young he equipped for himself a work-shop and laboratory in the garden at Hollowforth, and like many boys started experiments on explosives. Unlike most boys, however, he continued such experiments throughout his life and became one of the first authorities on the subject. He did not succeed without personal injury, for at an early age an explosion blew off the third and little fingers of his left hand as well as the top joints of the right thumb and index finger, and incidentally shattered his ambition to become a Royal Engineer. It is recorded that on the way to the hospital he insisted in having his mouth propped open by a piece of wood so that, if he should get lock-jaw, he should not be starved to death as well. It is also recorded that he continued his experiments on explosives when he went to Clifton College in January, 1873, to the satisfaction of his schoolfellows but not altogether to the approval of the masters. With what aid he could get from the village nearby he also taught himself the use of tools, and amongst other things successfully constructed a telescope, made a hydraulic ram to supply water to the garden and, at the request of his mother, fixed up a workable telephone between the garden laboratory and the house in the vain hope that occasionally he could be induced to return punctually for meals. His mother, like the mothers of many great men, had a great influence on him, and he used to speak of her not only with the deepest affection but with the greatest respect for her wisdom and judgment. From the time he made his first experiments to the end of his life, for a period of over sixty years, there were very few working days in any year when Threlfall was not to be found for some period experimenting in his laboratory.

When Threlfall first went to Clifton, Percival was the headmaster. They were great days at Clifton; he had as schoolfellows many boys who made their mark in different ways, including four future Fellows of the Royal Society. For some time he shared a study with the future Lord Haig. It is often said that one way to be great is to choose one's parents carefully; but many instances lead one to believe that it is just as important to select one's schoolfellows with equal care: or is it possible that great schoolmasters have a more permanent effect on their pupils than they are usually credited with?

Threlfall was a keen member of the Rugby fifteen at Clifton, and also a member of the shooting team. He left school in 1880, and went to Gonville and Caius College, Cambridge, with an entrance scholarship. Again he found himself with contemporaries of equal ability, one of them being a future President of the Royal Society, Sir Charles Sherrington.





[*To face p.* 186.

The photograph of Sir Richard Threlfall as a young man is taken from a group photographed by Dr. Alexander Scott in 1882.

In his second year at Cambridge, he produced the first automatic microtome, and by doing so made a contribution of the first importance to experimental biology. No account was published by him for nearly fifty years, when he communicated the history of this development to *Biological Reviews* (Vol. V, Oct., 1930). The history in brief is as follows :

The method of cutting sections before 1882 was to embed the specimen in paraffin and cut the sections by hand with a sharp razor. The instrument, such as it was, consisted of a glass plate with a central hole, through which a brass tube could be pushed by means of a micrometer screw. The brass tube carried a lump of paraffin on to which a piece of paraffin containing the embedded object could be melted. By this primitive method, it was impossible to get a uniform thickness of section; some sections might be three or four times as thick as others.

In May, 1882, W. H. Caldwell noticed that, if the paraffin was of the right consistence, the section adhered to the razor at the sharp edge of the blade, and did not adhere elsewhere. In cutting a second section without moving the first from the razor, the second section welded itself to the first when pushed across the razor. He happened to tell Threlfall of this observation and one of them remarked that it seemed to make the construction of a section-cutting machine a possibility. Afterwards they discussed the general ideas for a machine while on a trip to Heligoland. When Threlfall returned to Cambridge he started on the work with enthusiasm. From that time he had no help whatsoever from others. The design was completely his own, and he had the machine constructed in Professor Stuart's workshop at his own expense. He does not seem to have had any encouragement while the machine was in process of construction, indeed, the few comments he received were definitely discouraging. However, it was completed in 1883 and was a brilliant success from the first trial. Threlfall himself used it to cut an amphioxus into uniform sections about one four-thousandth of an inch thick, making a ribbon some yards long. He completed the work by developing a satisfactory method for dissolving away the paraffin and fixing the sections on to slides. Subsequently the rocking microtome was developed by Horace Darwin, but there is no doubt at all that Threlfall was the originator of the first practical machine. He records in his paper that when he was later at Strasburg, he told one of the demonstrators there about the construction of the microtome and the method of section mounting, and subsequently found a paper published in Germany giving all the information without any reference to the source from which it had been acquired.

In 1882 Threlfall took a first-class in Part 1 of the Natural Science Tripos. In the spring of the next year he took advantage of a new regulation which allowed candidates for the Science Tripos to spend a period up to one year in work abroad, and went to Strasburg to work with Fittig and Kundt from April, 1883, to the end of the semester. He always looked back to this time as one of great profit and pleasure to him. He seems to have taken a particular liking to Kundt, and the attraction was evidently mutual. He visited him in after years, and after his death referred to him in these terms in an anniversary address delivered to the Royal Society of New South Wales in 1895 :

" Before all things, Kundt was what the Germans call ' gemüthlich '—a jolly fellow. His method of teaching was copious and admirable conversation in the laboratory, and there probably never was a teacher who had so strong a hold upon his pupils—a hold both of heart and head. He was a thorough German, too. His surprise at seeing me, a man who had been to Australia and actually returned, was exquisite. He was even late for lecture to celebrate the event. ' Eheu fugaces '—the least of all thy servants bids thee adieu, dear master, there is no other man like thee."

In 1884 Threlfall took a first-class in Part 2 of the Natural Science Tripos. During his undergraduate career he continued to work hard in the laboratory at home as well as at Cambridge and to read widely and untiringly. He was a member of the University Dramatic Society and once played the part of Heracles in " The Birds " of Aristophanes. The " property " club with which he was provided was too light for him to wield with verisimilitude and he insisted on having a genuine solid article, which others could hardly lift. He was a famous Rugby football player and was captain of the Cambridge team at the time of an historic incident. No full " blues " were then given except for rowing and the blues committee consisted naturally of rowing men. Threlfall renewed an application for an award of this much coveted distinction to the Rugby team but was refused. In his characteristic manner he took matters into his own hands and ordered his team to appear in full blues against Oxford. This led to a first-class row, and to a debate at the Union at which all members of the University were allowed to be present. Sir Joseph Thomson has given a vivid account of the scene in his obituary notice of Sir Richard Threlfall published by the Royal Society :

"The room was so crowded for some time before the proceedings began that when Threlfall, on whom the hopes of the Rugby supporters rested, arrived, he could not get beyond the crowd at the back of the room, and had to be held up by some friends while he made his speech. The speakers before him delivered carefully prepared orations which smelt very much of the lamp, and left the audience quite cold. When he got up and jerked out from his uncomfortable stance one short sentence after another, full of good sense, good humour and good jokes, he soon had the house rocking with laughter and put the issue beyond doubt."

The only thing I need add to this description is that one of the friends on whose shoulders Threlfall precariously rested was Sir Joseph Thomson himself.

It is not difficult to recapture something of the impression that Threlfall made at this time of his life. He must have been quite out of the ordinary. His love of country life, and his skill at sport as well as at games, had developed a naturally powerful frame. He was a good shot with gun and rifle, and a good fisherman and remained so for the rest of his life. He had an unusually wide range of interests. He was passionately fond of flowers, a taste which he had probably acquired first on his visit to Switzerland as a boy when recovering from the accident to his hands. He had, indeed, a tremendous zest for life, which he seems to have communicated to all with whom he came in contact. He had too a full measure of that uncommon quality called commonsense, which shone in his speech and in his actions. After he had taken his degree, when he was in his fifth year at Cambridge, he took some pupils at Caius and also demonstrated in the Cavendish, and in the Caius laboratory under Pattison Muir. One of his first pupils was W. B. Hardy. Here is a description of the first interview :

"In the room I found a rather thick-set figure with a strong face and clad in a B.A. gown. Threlfall was then the most influential person in the undergraduate life of the College. He was, I think, the senior bachelor, and the gulf between the senior bachelor and a freshman is, as everyone knows, more awe-inspiring than that between the latter and the Master; the Master is merely someone unknown in the clouds.

"My first lesson in physics from Threlfall began, as might be expected, by a totally unexpected attack. 'What is a yard? ' he asked. Now, no teacher of physics at school had ever asked me such a silly and embarrassing question. A yard was a thing one took for granted. I blundered along with some sort of reply only to be cut short with : 'A yard is neither more nor less than the distance between two marks on a certain rod of platinum.' And from that, to me, new and rather staggering information he passed to the relation between measures and things measured. It was his way through life to ask the question, obvious when asked, which set of people wondering whether they had not committed the nursery trick of mankind—picking up the wrong measuring rod."

Threlfall had no opportunity for a Fellowship, which in those days were few and far between. No easy road to an academic career existed by way of postgraduate scholarships, or studentships for training in research : but then Threlfall did not need a training in research ; he had trained himself, and only needed the encouragement and inspiration of others. There is a paper of his on the theory of explosions published in the *Philosophical Magazine* for March, 1886, when he was not quite twenty-five, which gives a clear impression of his capacity and maturity. In this research he set himself to examine how the shock of an explosion was transmitted under water, and to test the existing theories of the mechanism by which one explosive might be exploded by the detonation of another at a distance. He carried out a series of experiments in his own garden at home, detonating small charges of fulminate of mercury in a wooden tank measuring about a yard each way, filled with water, and measuring the effects with homemade pressure gauges. The interest of the paper lies now not so much in the results obtained, although they were novel at the time, as in the ingenious and inexpensive methods used, and in the evidence it gives of Threlfall's mastery of experimental work, confidence in his own powers, and ability to express himself forcibly. While at Cambridge during these years he also collaborated with the then young Professor J. J. Thomson in various researches, including one on the effect of electrical discharges through nitrogen at low pressure. They reached the tentative conclusion that an allotropic form of nitrogen was formed under certain conditions. A few years afterwards, in 1889, Threlfall returned to this work, and showed that what actually happened was that an unstable compound of nitrogen was formed with the mercury present in the apparatus. It took him over two years to settle the point and his paper on the subject (*Phil. Mag.*, 1893, **35**, 1) is devoted largely to a detailed description of his efforts to prepare pure nitrogen from various sources. It is of interest to note that had he had occasion, at this time, to measure the density of his samples of nitrogen, he might possibly have anticipated the discovery of argon by Lord Rayleigh in 1894.

In 1886 Threlfall was offered and accepted the Professorship of Physics in Sydney University. He took Sydney by storm. Even in these days in England, when no one is surprised that a distinguished Professor should be an ordinary-looking and even a capable individual, the appointment of a young man of the age of twenty-five, better known to the outside world for his athletic fame than for his intellectual attainments, would excite some comment. But fifty years ago in Australia, where brawn was undoubtedly considered more important than brain, the appearance of such a man was greeted with enthusiasm. A correspondent to *The Times* at the time of Threlfall's death wrote of the " deep impression Threlfall's personality made upon the students of the University of Sydney and the far-reaching influence he exerted. A professor who not only took an interest in football but actually played with the University team was a new phenomenon. But Threlfall did much more on the football field than give practical instruction in Rugby tactics. Although his vocabulary was regarded as adequate, even for Australia, he would not tolerate any liberties. He taught the team many lessons in social practice, which were not wholly unnecessary.

" It was, however, as a teacher of physics that his dominating personality exerted most influence in Australia. He gave many undergraduates a new conception of the methods and meaning of science. His first lecture is deeply impressed upon the writer's memory, his experiments to demonstrate smoke vortices and to interpret J. J. Thomson's theory of matter and energy, his impressive warning that science did not teach dogmas but should be ever alert to modify its theories in adaptation to new facts revealed by experiment. No less surprising to many of us, who until then had imagined that science had a definite doctrine to inculcate, was his advice to read Draper's ' Conflict between Religion and Science,' and learn to distinguish between dogma and the open mind. It would be difficult to assess the effects his robust personality exerted in Australia by inculcating the true scientific attitude.

" His manner with students this personal experience will illuminate. The writer was awarded the only University prize in physics. Threlfall sent for him and said, ' Don't run away with the idea you know anything of physics : you were simply the least unsatisfactory of a poor lot.' "

Threlfall arrived in Sydney to find no physics laboratory and threatened to go back unless one was provided. At first he was given a few unsuitable rooms, and vague promises of better things; but nothing could stop him from experimenting, and he soon made friends with the naval and military authorities, and with their help, and with the collaboration of J. F. Adair, then demonstrator of physics in the University, started towards the end of 1886 on a closer investigation of the alleged " explosion by influence." He finally disposed of this phenomenon by proving that it did not exist, and went on to measure the velocity of transmission of the shock of explosions through water. He succeeded in showing that the velocity was greater than that of sound, and increased substantially with the size of the explosive charge. A full description of the work was published in the *Proceedings* of the Royal Society (1889, **46**, 496).

Meanwhile his pertinacity in pressing for a suitable laboratory, and his capacity for making friends with everyone, had their reward. In Sir Joseph Thomson's words :

" One night the Prime Minister came up to him in the club and said ' Dick, I have done the square thing by you at last. I've put your laboratory on the estimates. We've just been beaten on a division and are resigning to-morrow so that the other fellows will have to pay.' "

The vote in the first place was for £8000, afterwards increased to £13,000, which probably corresponded to an expenditure of about £7000 in England. The building was begun in February, 1887, and handed over in June, 1888. There is an interesting description of it, written by Threlfall, in the *Proceedings* of the Australasian Association for the Advancement of Science, in 1888. One part of this description is worth quoting because, although written nearly fifty years ago, it seems singularly apposite at the present time, and shows Threlfall's attitude towards experimental work :

" In my experience experimenting is neither more nor less than doing a number of small jobs; one's thoughts are always far ahead of the particular part of an experiment one may be engaged on ; and hence the quicker we can make the satisfaction of our experimental needs, the more efficient will our work become. It is for this reason among others that I prefer a good big place to work in—a place where every part of an experiment can be done—and where loss of time through running about shall be reduced to a minimum. Even for purposes of instruction I utterly fail to see the advantages arising from the use of antiquated or inefficient appliances. Experimental facility can I believe be acquired just as well by working with good tools as with bad ones : and the amount of ground got over is greater, the greater the efficiency of the appliances. Of course I do not mean to say that students should be furnished with all their experiments ready set up—this I believe to be a great mistake—I think the best work for students is the most difficult and tiresome, and that requiring the greatest accuracy—but why should we add to that the annoyance of insufficient or make-shift appliances? I am of course talking of physical work—in such cases as Mineralogy—where the student will in after times have to work with meagre instrumental assistance, handiness and a power of adaptation of things to want, are the most valuable possessions that education can furnish : so that much apparatus may in this case be a bad thing. But this is not to any extent the case with Physics. It is true of course that many great men have performed great experimental feats with the simplest of apparatus; but the contemplation of such cases has always stirred within me some feeling of regret that the means were so inadequate, and this has quickly overpowered the feeling of delight in the results attained. On the whole I conceive that the work done in a Physical Laboratory is not unlike the work done in an instrument maker's shop; and that both should be constructed on the same principle of time-saving."

This, it should be noted, is the opinion of a man quite outstanding in his experimental ability.

For the next eleven years, with the help of members of his staff, and research assistants, Threlfall was very busy with a variety of researches. That on the effects of electrical discharges through pure nitrogen has already been mentioned. His study of dielectrics extended over many years, in the course of which he was led to examine the Clark cell as a source of small standard currents, to develop methods for the measurement of high specific resistances, and to design and construct a galvanometer to measure currents as low as $10^{-13}$ ampère. He made an elaborate series of researches on the preparation of pure sulphur, and on its electrical properties. He was quick to realise the importance of the discovery in 1889 by C. V. Boys of the properties of fine quartz threads, repeated and extended the method of production invented by Boys, and made exact measurements of the elastic constants of the threads. He made use of the quartz thread in the development of an instrument for the comparison of the force of gravity at different places. With this instrument he and Pollock, who eventually succeeded him as Professor, travelled over 6000 miles in Australia and Tasmania, taking observations. In spite of rough usage, only one quartz thread was broken, and one lasted for over 4500 miles. The accuracy of measurement by this instrument proved to be as high as 1 part in 500,000. An account of the work was published in the *Philosophical Transactions* in 1900 (**193**, *A*, 215), and Threlfall exhibited the instrument at the meeting of the British Association in Dover in 1898. It was then returned to Australia but remained stored in a cellar for twenty-seven years, when it was sent back to England. On examination it was found that the quartz fibre and its suspension were undamaged, but the rest of the apparatus was in such bad order that Threlfall had it entirely reconstructed. With the help of Dawson he then used it for the comparison of gravity at the National Physical Laboratory, and at Kew, and gave an account of this work to the Royal Society a few months before his death.

In 1898 he published his book on "Laboratory Arts." He seems to have had some difficulty in finding a publisher at first, but the book was a great success, and "go to Threlfall" was advice frequently given and acted upon. It is a storehouse of valuable information on laboratory technique, and, with a few trivial exceptions, all the directions and suggestions it contains are derived from the author's own personal experience. All the illustrations in this book were drawn by his wife. Towards the close of his life he was engaged on, but did not finish, a new edition of this work.

In 1890 he returned on holiday to England, and paid a visit to Professor Van der Waals in Holland, with whom he discussed certain difficulties in the latter's famous paper of the continuity of the liquid and gaseous states of matter, an English translation of which by Threlfall and Adair was later published as a Physical Memoir. Threlfall used to say that the discussion with Van der Waals was conducted by an exchange of notes written in dog-Latin.

He married in 1890 Evelyn Agnes Baird, who was one of six talented daughters of John Forster and Emily Jane Baird of Bowmont Hill in Northumberland. One of Lady Threlfall's sisters was well known as Dorothea Baird, who married H. B. Irving, and another married A. L. Smith, afterwards Master of Balliol College, Oxford. Lady Threlfall was an unusually clever woman; she had a most retentive memory and an "extensive and peculiar" acquaintance with the works of Dickens. She published two volumes of poems: Starlight Songs (1895), and The Shore of Dreams (1907). She died in 1929, when Sir Richard was returning from Japan where he represented the government at the World Power Conference. Four sons and two daughters survive them.

The general impression left by a study of Threlfall's scientific work in Australia is that he continually added to experimental knowledge without making such a contribution to scientific progress as might have been expected from a man of his remarkable ability. It would be fair to say that he was really too interested in the details of experimental work, and the fact that the difficulties of some experiments were too great for the immediate end in view never led him to attack anything more promising; on the contrary the bigger the experimental difficulties the more he seemed to be stimulated to overcome them. These are pre-eminently the qualities required in applied Science, but do not necessarily lead to notable success in pure Science. Threlfall enjoyed the frontal attack, and did not believe in inspiration although perhaps some of his own work owed more to inspiration and less to exact scientific reasoning than he imagined. In an address to the Australasian Association for the Advancement of Science in 1895, he referred to the discovery of argon, and added:

"I cannot close this brief notice without directing your attention to the magnificent triumph which this discovery has obtained for the method of enquiry by means of prolonged, laborious, and exact measurement as opposed to the method of happy inspiration. Contrary to the popular idea, the vast majority of discoveries have been made by the methods employed by Lord Rayleigh, of which the essence is that no obscurity, however small, is to be passed over until it is completely sifted."

It was typical of Threlfall that he could not leave any obscurity alone, and it was unfortunate that none of the obscurities to which he gave so large a share of attention and examined with so much skill led to any outstanding advance in Science.

In the midst of his scientific work he found time to carry out a fair amount of work as a consultant; an experience which was valuable to him later on. He was also president of the Royal Commission of the Spontaneous Combustion of Coal. This Commission was appointed in 1896 and issued a report of the first importance a year later. He was President of section A of the Australasian Association in 1889/1890, and delivered an address on "The Present State of Electrical Knowledge" in the course of which, after discussing the work of Maxwell and Hertz on electromagnetic waves, and describing methods for their detection, he indulged in a prophecy which has since been amply justified. " If it be permissible to prophesy wildly, we may see in this observation the germ of a great future development." He was also President of the Royal Society of New South Wales in 1895. It need hardly be added that during his stay in Australia Threlfall found time to see much of the country, including New Zealand and Tasmania, and to indulge in his love for outdoor sports.

In spite of his manifold activities, his friendships and his affection for the place, Threlfall never felt quite secure in his position in Australia. Seven years after he had got his laboratory, in a reference to the work of Helmholtz, who had recently died, he said that Helmholtz " recognised that in physical science stagnation means retrogression, and that the man who has not the curiosity to attempt to widen our common knowledge is not fit to set himself up as a teacher, nor are the pupils of such a man likely to receive any lasting benefit. If Helmholtz's words, so fruitful first through Germany and France, and then through England and America, could find even at this late date some echo in the Colony, we might be gradually educated up to seeing that the commercial value of a teacher is not to be measured by the number of hours of lecture that can be dragged out of him, nor is a laboratory to be regarded as an expensive luxury to be blown away at the first breath of retrenchment." He was out of touch with many of his scientific friends, the nearest being W. H. Bragg at Adelaide. His wife's health suffered in the climate of Sydney, and he had to think of the problems of a young family now fast growing up. When he came back to England for a visit in 1899 it was with the intention of finding work at home, but no suitable Professorship seemed likely to be vacant in the near future, and after full consideration, he decided to accept an offer to join the well-known firm of Chemical Manufacturers—Messrs. Albright & Wilson in Birmingham. That the decision was a wise one there can be no doubt. The particular range of activities of Messrs. Albright & Wilson was exactly suited to Threlfall's interests; applied electrochemistry was a subject which exercised to the full his profound knowledge of physics and chemistry and his ability as an engineer. He settled down in Birmingham in 1899, and for fifteen years devoted himself entirely to the affairs of the firm ; in his own words he became : " a type of man wholly immersed in provincial business." As it happened he saw little of his scientific friends during this period, visiting London and Cambridge not more than two or three times a year : and apart from being a member of the Council of Birmingham University, of one of the Committees which led to the formation of the Imperial College of Science and Technology, and of the Royal Society Committee on Electrical Units, he did little outside work. On the other hand, fifteen years of strenuous technical research at Oldbury gave him a unique knowledge of chemical and physical methods as applied to manufacture. He worked out a method for the electrolytic manufacture of sodium chlorate which was operated successfully on a large scale at Niagara Falls. He also developed a method for the electrolytic production of zinc, which was a magnificent triumph over experimental difficulties, but unfortunately was not adopted in the end, as it proved for various reasons to be uneconomic. The only advantage of this decision was that it gave him the opportunity to publish an account of the work in the *Journal* of the Society of Chemical Industry in July, 1929, on the occasion when he was given the Gold Medal of the Society. A remark in this paper is characteristic of him. After referring to the formidable experimental difficulties, he says " However, I decided in the end that such difficulties as might arise could probably be overcome by steady work and engineering." He also introduced many improvements in the production of phosphorus by the electric furnace and installed a large gas engine plant to which reference will be made later. No details of Threlfall's work during this period can be published other than those which have already appeared in various journals. In an address on some problems of electrochemistry to the Birmingham local centre of the Institution of Electrical Engineers in 1905 Threlfall said :

" Reticence is a tradition of the chemical industry, and the introduction of processes based on electrochemical operations has, if anything, increased the habit of, as well as the necessity for, uncommunicativeness. The manufacturer of machinery has really no secret except his organisation—the machines he sends out speak more or less for themselves, and render it futile to endeavour to conceal matters of design or construction. The products of a chemical works, however, do not necessarily indicate their mode of manufacture. . . . It would require very expert knowledge to decide whether a sample of chlorate of potash was manufactured electrolytically or from chlorine."

One result of this reticence was that much of Threlfall's unique knowledge of electrochemistry died with him; which is perhaps as unfortunate in the long run for the progress of industry as it is for the advancement of science. Threlfall himself was apt to be somewhat contemptuous of the academic electrochemist; he used to say that many of the statements in text books on electrochemistry were misleading if not absolutely wrong.

The nature of his work made it necessary for Threlfall to be concerned in the production of electrical power on a large scale at Oldbury. For various good technical reasons, it was decided to install a gas engine plant, the only suitable engines for the purpose being obtainable, at the time, in Germany. In the course of his work on the design and general arrangement of the plant, Threlfall was led to study the efficiency of electrical generators in 1901. The testing of alternators was then in a very primitive state and the uncertainty of the results of measurement of efficiency was a serious difficulty to the manufacturer and users of large alternators. In some installations it was practically impossible, owing to constructional peculiarities, to measure the brake horse-power developed by an engine under running conditions. Threlfall got over the difficulties in a most ingenious way, by enclosing the alternators in a non-conducting casing, pumping air through the system at a measured rate, and ascertaining the rise of temperature of the air on entering and leaving the system. He published a full account of this work in the *Journal* of Proceedings of the Institution of Electrical Engineers in 1903. It gave rise to considerable interest and discussion, the general opinion of engineers being that it was the kind of a thing only a physicist could do. Threlfall pointed out in answer to the discussion that the method was quite amenable for use by anyone who was accustomed to exact measurement, and that no other sufficiently exact method appeared to be immediately available for users. The method involved exact measurement of the velocity of air in the ducts, and for this and other reasons Threlfall spent some time on the theory and use of the Pitot tube method. He published the results of these researches in the *Proceedings* of the Institution of Mechanical Engineers, February, 1904: the paper and discussion are of interest in showing Threlfall's combination of scientific knowledge and technical judgment. For instance he makes the following characteristic remark:

"Professor Unwin's remarks on matters of theory were based on the hydrodynamics of frictionless fluids; no doubt the author's treatment was lamentably defective, but it had the merit of not taking for granted that producer gas would behave so nearly like a frictionless fluid that calculations involving large sums of money could be safely based on that hypothesis."

Threlfall also spent some time on the development of apparatus to withstand high pressures and temperatures, and used it to examine the possibility of producing diamonds from carbon, a subject which created much interest at the time. It was not altogether without value for his own purpose, because he was studying the properties of carbon for other reasons.

In 1914, just before the outbreak of war, the large gas engine plant was completed at Oldbury. For fifteen years Threlfall had worked in some obscurity, so much so that when the war broke out it seems to have occurred to no one at once to enlist his help in the many technical problems, the solution of which immediately became urgent. He offered his services to the Admiralty and to the War Office, but was told that he was too old. He was then fifty-three. It was only through his own enterprise that he became eventually closely concerned with national affairs. About the end of October, 1914, he read a statement subsequently shown to be untrue, that the Germans were using a non-inflammable gas in their air-ships. Knowing the German competence for big engineering projects, he wondered whether it was within the bounds of possibility that they had got a practical source of helium from gas wells or coal mines. On looking through the available literature, he found the record of a gas well near Hamburg with a relatively high percentage of helium. He brought this to the attention of the Admiralty and was asked to investigate the matter further. He then found a record in the transactions of the American Chemical Society to the effect that a gas well in Kansas had given upwards of two per cent. of helium. At his own expense he arranged for one of his collaborators at the Niagara Falls branch of Messrs. Albright & Wilson to collect samples from the well and to analyse them. The analysis confirmed the original statement, and subsequently samples were sent home and analysed by Sir William Ramsay, who got confirmatory results. Threlfall then worked out a general scheme for producing the gas in quantity and arranged for other experiments on the diffusion of helium through balloon fabric. For very good reasons it was decided not to proceed with the scheme at the time, but a grant was made by the Admiralty to Professor MacLennan to enable him carry out further experimental work in Toronto. Subsequently, as is well known, helium was produced on a large scale in America, and Threlfall's predictions were fulfilled.

As a result of this work on helium, he was invited by the Admiralty to serve on a committee of the Naval Board of Invention and Research which had been formed in 1915. Although his work was at first confined to matters arising from the helium projects, his services were soon enlisted in other directions, and he became very closely concerned with a variety of naval problems. From then onwards his war work rapidly extended. No details of it can be given, but it is no secret that he was the originator of phosphorus bombs and of methods of production of smoke screens, which were used successfully on an enormous scale. On one occasion he was asked to produce some special bombs in a hurry for use in France, and he and his staff, working day and night, designed, tested, manufactured, and sent off one thousand of the bombs required within a fortnight. They arrived in time to be used with devastating effect for the destruction of enemy kite balloons before the Battle of the Somme.

After the War he wrote a short confidential account of his work and experiences, including impressions of the principal people he met. Those who knew Threlfall well can imagine that these notes make interesting and entertaining reading, and will also readily accept the statement that they are not for present publication.

All this war work, disturbing as it must have been at first to the normal course of his life, was of great advantage to Threlfall. It widened his interests, gave him greater scope for his powers, and caused him eventually to be concerned with national work of a permanent, as well as of a temporary, importance. The lack of scientific preparation that was so obvious in 1914 led the Government to set up in 1915 an Advisory Council for Scientific and Industrial Research, not only for war purposes, but with the more long-sighted view that it would be necessary for the promotion of science and industry after the War. Threlfall was one of the original members of this Council and served continuously for a period of ten years, after which he continued to be associated with the Department of Scientific and Industrial Research until his death. He enjoyed this period of his life as much as any. He threw himself with the greatest enthusiasm into the plans of the new organisation and was undoubtedly the hardest worked, and the hardest working, of all the distinguished members of the Advisory Council. He took an immense amount of pains; nothing was too great a trouble for him to do. He believed in the work, he enjoyed the discussions, and being a man with so great a capacity for friendship, he enjoyed also the opportunity of renewing his old friendships and making new ones. His criticism could certainly be trenchant, and his strongly individualistic temperament inclined him at times to doubt the wisdom of some of the plans for organising Industrial Research. I can see him now, sitting at the Council table with a sardonic gleam in his eye, while someone over-elaborated a " scheme of research." Nevertheless, he showed his essentially scientific habit of mind by always being prepared to make a reasonable experiment in administration as well as in science. His influence on the Department can hardly be over-emphasised. Other great industrialists have been associated with the Advisory Council, but none who had so wide a range of knowledge and experience of the academic and industrial worlds as Threlfall, and none with quite his sense of proportion. He combined the practical qualities of an engineer with a profound and sincere belief in the value of research, not only for its own sake, but as a necessary preliminary to industrial progress.

One instance of his foresight may be given. When he became Chairman of the Fuel

Research Board in succession to Sir George Beilby, he strongly urged the necessity for research on the design of industrial furnaces. In his view the design of furnaces had always been empirical; and although the process of trial and error over a number of years had often led to results in industry which would be difficult to improve upon substantially by scientific research, it had failed in this case, and large sums of money were wasted annually because there were no sound principles of design. He maintained that no substantial advance would be made until much more knowledge was available on the transfer of heat from hot gases; and he put forward a plan for the scientific study of the problem, with the warning that it might be many years before practical results emerged. His advice was followed; and a small staff worked under his general guidance. His predictions have been entirely fulfilled; our knowledge of the subject has been greatly extended, and has already been applied with success to large-scale operations. Threlfall was also responsible for starting the Government Chemical Research Laboratory at Teddington, and gave much of his time to its design and equipment. He was Chairman of the Chemistry Research Board, and acted as part-time Director of chemical research until the appointment of Sir Gilbert Morgan.

It is of interest that in 1919 he was asked whether he would allow his name to go forward for the Directorship of the National Physical Laboratory in succession to Sir Richard Glazebrook. After serious consideration he decided against this; he was certainly wise in doing so, for at the National Physical Laboratory he would have had little time for the individual work which was part of his very nature, and the large amount of administrative work which is so unavoidably associated with the direction of a big government research laboratory would have proved irksome to him. He remained at Birmingham, his main work for the firm after the War being the improvement of methods for the manufacture of carbon tetrachloride, the manufacture of glycerophosphates, and the manufacture of carbon disulphide. The gas engine plant which operated with success for the whole of the War period was shut down and sold as scrap in 1919, because it was no longer useful from a commercial point of view. Threlfall parted with great regret from the machinery to which he had devoted many years of brilliant work; but that is one of the drawbacks of industrial life; the best work often bears fruit for too short a time.

Threlfall was elected a Fellow of the Royal Society in 1899 and an Honorary Fellow of Gonville and Caius College in 1905. He was also created K.B.E. in 1917, and G.B.E. in 1927. He was given an honorary degree of D.Sc. by Manchester University in 1919, and was made an honorary Associate of the Manchester School of Technology in September, 1930. As has already been mentioned, he received the Gold Medal of the Society of Chemical Industry in 1929. After some months of gradually failing health, he died on July 10th, 1932, at Edgbaston.

Threlfall's life in retrospect seems to be divided into three quite distinct phases. The first covers his academic career, during which, starting from nothing, he built up a school of experimental Physics in Sydney, and succeeded in leaving behind him a spirit of research that has never deserted the University. He went to Australia at a time when Science was almost completely neglected; and that it is now a country where, in proportion to the size of the population, Science plays as great a part in national affairs as in any other country, is surely due in no small measure to his lasting example and inspiration. He then abandoned his purely scientific work to become a comparatively unknown, but outstandingly successful chemical engineer and manufacturer. In the third and final phase of his life, in the fullness of his powers, with years of hard-won experience behind him, and with inexhaustible energy, he rendered service of incalculable benefit to his country. In all these phases of his life he excelled. " And yet," his life-long friend Sir W. Hardy wrote in the Caian for 1933, " to me, knowing his great gifts, those successes never seemed enough. With his gifts of character, of mind, and of speech he might have been, and somehow he ought to have been, a great public figure. He was far and away bigger and wiser than most of the public men I have met. The answer as I see it is simply that he did not want to be in the limelight. His ambitions were of the homely friendly sort. The judgment of his scientific friends of the Royal Society was a thing which mattered greatly to him, and in the main he just did the job that came along."

H. T. TIZARD.