OBITUARY NOTICES.

ERNEST HAROLD FARMER.

1890—1952.

ERNEST HAROLD FARMER was born on March 3rd, 1890, at Longford—a village in the agricultural district of west Derbyshire. His education he received at the Municipal School, Derby, and later at the University College, Nottingham, where he studied chemistry under Professor F. S. Kipping, F.R.S., graduating B.Sc. in 1911.

He chose teaching as a career and held appointments first at Daventry Grammar School and then at the Municipal School, Bury (Lancs.); but the incident at Sarajavo in 1914 changed the course of his whole life. He immediately volunteered for military service, entered the Inns of Court O.T.C., and was gazetted in 1915 to the Loyal North Lancashire Regiment in which he served until his demobilisation in 1919. He fought in Flanders until in 1917 at the Battle of Messines he was severely wounded in the head and right arm. The elbow joint had to be excised, and the severed ulnar nerve had to be sutured leaving him with partial paralysis of his right hand, whilst his head injuries left him partially deaf. After alternating between hospital and convalescent home for nearly two years, he was seconded for service with the Ministry of Munitions and returned to work at his old College under Professor Kipping. In 1919 he was still in uniform when he went to the Imperial College of Science and Technology (Royal College of Science) to start his researches in the organic laboratories of Professor J. F. Thorpe, C.B.E., F.R.S.

His boyhood recreations, which centred round playing the violin and church organ, were now no longer available and Farmer devoted himself whole-heartedly to his research, working long hours into the night. He graduated M.Sc. and D.I.C. in 1921 and was awarded the D.Sc. (London) in 1924 for his Thesis entitled " Some Aspects of Conjugation."

The same year he was appointed to the teaching staff of the Royal College of Science and was placed in charge of the Wiffin Laboratory (organic preparations in semi-scale plant) with Assistant Professor Martha A. Whiteley, the late Dr. G. A. R. Kon (subsequently Professor at the Chester Beattie Hospital) and Dr. (now Professor) R. P. Linstead as his colleagues. The Department of Organic Chemistry under the jovial Professor Jocelyn Thorpe was a happy one. Farmer soon gathered round him a small group of enthusiastic research students, and the congenial atmosphere of the laboratories was only marred by the lachrymation from brominated butadiene.

It was against this background that Farmer was able to set aside the disasters of war. A dinner and a show in town with his research students were not infrequent, and he enjoyed an evening of recorded classical music or singing around the piano old English songs, whilst every summer saw him on the Continent for a few weeks.

Farmer was very friendly with his students and took a real interest in their extra-mural activities and maintained this long after they had left his laboratories. When research assignments dictated their working well into the night, Farmer would generally look in the laboratory to say a cheery word at anytime between midnight and dawn. It was quite apparent, however, that the sufferings of war could not be entirely forgotten. He found it difficult to shake out bulky solutions for which he sought the willing help of his research students; and before he went into lectures an arm support had to be laced on to assist his writing on the black-board. Only a few knew of these disabilities, and the writer has hesitated to record these facts which Farmer so carefully concealed. It was characteristic of Farmer not to solicit sympathy. He was a man of straightforwardness and entire lack of any form of pretence or falsity.

In 1930 he married one of his research students, Miss Marjorie J. Wilson-Smith, at St. Luke's, Redcliffe Square.

In 1932 Farmer was invited by the Rubber Growers' Association to undertake a series of investigations on the chemical modifications of rubber with the object of producing semi-artificial materials suitable for use in industry. These studies were carried out concurrently with teaching duties and academic research. In 1938 he joined the newly formed Research Association of the British Rubber Producers as senior chemist. For the first year of his appointment he occupied the small Armstrong Laboratory at the Imperial College where he collected a small staff of four (Dr. G. F. Bloomfield and Messrs. Grey, A. Sundralingam, and D. A. Sutton).

He immediately embarked on ambitious projects of fundamental importance to rubber chemistry. In 1939 he moved with his staff to the new laboratories of the British Rubber Producers Research Association at Welwyn Garden City where he rapidly built up the new organic research laboratories. Within two years he was promoted to Assistant Director in which capacity he remained until ill health enforced his retirement.

In spite of his administrative responsibilities at B.R.P.R.A., Farmer always resisted the tendency to become a " desk-chemist " and he was perhaps happiest in opening up a new field of work by his initial experiments for his team to develop in detail. He was never in a hurry to publish and, although this sometimes exasperated his team, Farmer's published works contain few incorrect conclusions. He was friendly and helpful to his assistants and an excellent teacher of research methods. In later years he seldom took a holiday and had no patience with trade-union hours or what he believed to be the levelling down of a socialistic state.

" Distinguished for experimental studies of complex hydrocarbons and related natural products," Farmer was elected in 1948 a Fellow of the Royal Society. Unfortunately his health was already failing and in 1951 he was forced to relinquish his Assistant Directorship. His outstanding service, however, received recognition from the Association and he was appointed a Research Fellow and so he maintained his interest in its work to the end.

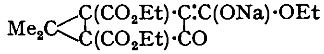
Apart from his love of music, which he derived from his early days as choir-boy, Farmer was very interested in gardening. He had planned to grow roses in his retirement and it was no little disappointment when he realised that this was to be impossible.

Farmer collapsed suddenly on Sunday, April 13th, 1952, as he was preparing to go to Church, and was buried in the picturesque little village church of Aldenham, Herts.

To his widow who assisted him so ably in home and laboratory must go the assurances that he was greatly esteemed by all who knew him, and the greatness of his work will be his permanent memorial.

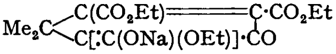
Farmer published with his collaborators over one hundred scientific papers, mostly in the *Journal*, and contributed to various books. He wrote the whole of the Aliphatic Division of Organic Chemistry for four consecutive years (1930—33)—a task which was later divided—and the chapter on polymerisation (1935) for the Annual Reports on the Progress of Chemistry.

Farmer started, as a research student, the reinvestigation with Thrope and Ingold (*J.*, 1920, **117**, 1362; 1922, **121**, 128) of the structure of the yellow *bicyclo*pentane (I), which Toivonen considered to be a *cyclo*pentene (II). The existence of a dynamic equilibrium was amply illustrated; and the concept of intra-annular tautomerism contributed later to the aromatic theory and dovetailed into another series of researches led by Ingold, and in which Farmer participated, on the conditions underlying the formation of unsaturated and cyclic compounds (*J.*, 1921, **119**, 2001).



$$Me_2C<\begin{matrix}C(CO_2Et)\cdot C{:}C(ONa)\cdot OEt\\ C(CO_2Et)\cdot CO\end{matrix}$$

(I)



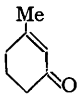
$$Me_2C<\begin{matrix}C(CO_2Et)=\!=\!=\!=C\cdot CO_2Et\\ C[{:}C(ONa)(OEt)]\cdot CO\end{matrix}$$

(II)

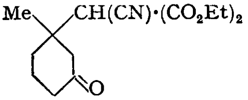
The study of the chemistry of the muconic acids by Farmer himself (*J.*, 1922, **121**, 2015; 1923, **123**, 2531, 3324; cf. also *J.*, 1931, 1762) followed naturally from his initial researches. This resulted in the explanation of the 1 : 3-type of addition of ethyl cyanoacetate to muconic acid ester (III) to give (IV) as due to a primary 1 : 2-addition followed by a double αβ : βγ change, and led furthermore to an attempt to synthesise substances having the Ladenburg formula (*J.*, 1923, **123**, 3332).

$$\underset{\text{(III)}}{CO_2Et\cdot CH{:}CH\cdot CH{:}CH\cdot CO_2Et} \longrightarrow \underset{\text{(IV)}}{CO_2Et\cdot CH_2\cdot CH_2\cdot C[CH(CN)\cdot CO_2Et]{:}CH\cdot CO_2Et}$$

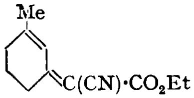
In 1924 Farmer was joined by his first research student, John Ross, with whom he extended his studies of the Michael condensation to cyclic unsaturated ketones (*J.*, 1925, **127**, 2358; 1926, 3233). The condensation of methyl*cyclo*hexenone (V) with ethyl cyanoacetate gave the



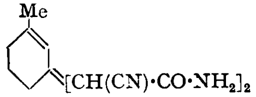
(V)



(VI)



(VII)



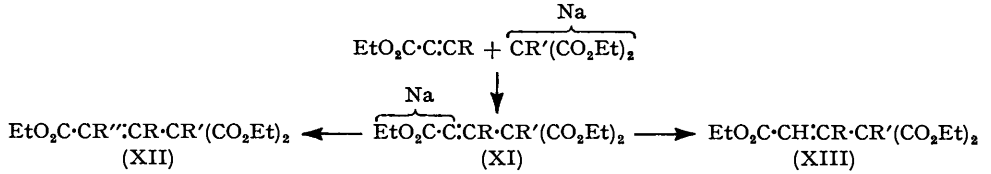
(VIII)

normal Michael addition product (VI), but the Knoevenagel condensate (VII) was found as a by-product. The treatment of this compound (VII) with ammonia, in an attempt to prepare the amide, gave compound (VIII), the formation of which was explained as the reversion of a portion of the cyclic ester into its generators with the subsequent αβ-addition of the liberated cyanoacetic ester to the undecomposed portion. The interpretation of this chance observation as an αβ-addition was at variance with the addition of malonic ester to methyl sorbate reported as an αδ-addition compound (IX) many years previously by Vorländer (*Annalen*, 1906, **345**, 227). Farmer (*J.*, 1927, 1060) confirmed initially Vorländer's observations; but in view of his findings on the additive behaviour of butadienoid hydrocarbons with bromine and hydrogen (see below) he restudied the Michael reaction on sorbic ester (*J.*, 1930, 1610) and successfully demonstrated the presence of the αβ-product (X). He extended the study to include triene esters and the effect of substitution on the proportion of isomerides (*J.*, 1933, 960; 1931, 1904, 2561), which did much to establish the mechanism of the Michael reaction in particular and to throw light on the anionotropic reactions.

$\mathrm{CH_3{\cdot}CH[CH(CO_2Me)_2]{\cdot}CH{:}CH{\cdot}CH_2{\cdot}CO_2Me}$ (IX)

$\mathrm{CH_3{\cdot}CH{:}CH{\cdot}CH(CH_2{\cdot}CO_2Me){\cdot}CH(CO_2Me)_2}$ (X)

The question of the division of the addendum of the Michael reaction was successfully resolved from a study of the addition of malonic esters to acetylenic esters (*J.*, 1936, 1804). The yellow sodio-derivative (XI) which was alkylated and hydrolysed only with difficulty to (XII) and (XIII) respectively, revealed the components as Na and $\mathrm{CR(CO_2Et)_2}$.



$$\mathrm{EtO_2C{\cdot}C{:}CR} + \overbrace{\mathrm{CR'(CO_2Et)_2}}^{\mathrm{Na}}$$

$$\downarrow$$

$$\underset{\text{(XII)}}{\mathrm{EtO_2C{\cdot}CR''{:}CR{\cdot}CR'(CO_2Et)_2}} \longleftarrow \underset{\text{(XI)}}{\overbrace{\mathrm{EtO_2C{\cdot}C}}^{\mathrm{Na}}\mathrm{{:}CR{\cdot}CR'(CO_2Et)_2}} \longrightarrow \underset{\text{(XIII)}}{\mathrm{EtO_2C{\cdot}CH{:}CR{\cdot}CR'(CO_2Et)_2}}$$

Farmer was necessarily influenced by the chemical thought being developed at the organic school in South Kensington. The Thorpe–Ingold strain theory undoubtedly led him to study the effect of *gem*-dimethyl groups on the formation and stability of anhydrides (*J.*, 1926, 2381; 1927, 680) and the dipole moments of 1 : 1-dicarboxylic esters (*J.*, 1933, 1904), and it was not unnatural that he should extend Thorpe's classical researches on the glutaconic acids (*J.*, 1926, 2171; 1927, 59).

The activities of Farmer's laboratory were, however, soon narrowed to a systematic study of the properties of conjugated compounds. The bromination of hexatriene, butadiene, and cyclic butadienes (*J.*, 1927, 2937; 1928, 729; 1929, 172) revealed 1 : 2-addition as well as terminal addition, whilst similar experiments with dimethylbutadienes indicated the significance of substitution on the proportions of the isomerides (*J.*, 1930, 510).

$$\mathrm{CH_2{:}CH{\cdot}CH{:}CH_2} \longrightarrow \mathrm{CH_2Br{\cdot}CHBr{\cdot}CH{:}CH_2} + \mathrm{CH_2Br{\cdot}CH{:}CH{\cdot}CH_2Br}$$

It was natural for Farmer not to remain satisfied with the small recorded differences in physical properties of the hydrocarbons used as his starting materials, and all during this period preparative methods for, and physical properties of, the butadienoid hydrocarbons formed a major project (*J.*, 1931, 3221; 1933, 1297, 1302; 1937, 1065).

Furthermore about this time Farmer included in his studies the isolation from natural oils of unsaturated acids, which were to be used later in experiments on autoxidation and thermal polymerisation. The structure of the first ketonic polyene acid, licanic acid (XIV) (*Biochem. J.*, 1935, **29**, 631) was established, whilst licanic and *iso*licanic acids were shown to correspond to α- and β-forms of elæostearic acid (*J.*, 1935, 1632; cf. also *J.*, 1935, 76, 1630; 1936, 1809). The acid, m. p. 85·3°, from the oil of *Parinarium laurinum* was assigned the formula (XV) (*J.*, 1935, 759) and was seemingly the first conjugated tetraene acid reported from vegetable or animal sources.

$\mathrm{CH_3{\cdot}[CH_2]_3{\cdot}[CH{:}CH]_3{\cdot}[CH_2]_4{\cdot}CO{\cdot}[CH_2]_2{\cdot}CO_2H}$ (XIV)

$\mathrm{CH_2Me{\cdot}[CH{:}CH]_4{\cdot}[CH_2]_7{\cdot}CO_2H}$ (XV)

The further extension of these studies to include the acids from fish oils presented difficulties of separation owing to the complexity of the mixture and the heat sensitivity of the components; but the perfection, in Farmer's laboratory, of molecular distillation of the mixed methyl esters from a falling film (*J. Soc. Chem. Ind.*, 1938, **57**, 24T; *J.*, 1938, 427) opened the way to the concentration, and elucidation of the structural features, of docosahexaenoic acid.

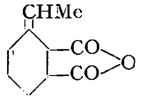
Concurrently hydrogenation experiments, initially on sorbic acid (XVI), established the 1 : 2- and 1 : 4-addition and so brought the addition of hydrogen into line with that of other common addenda although the reaction was more complex and hydrogenated bimolecular compounds were also formed (*J.*, 1930, 522) :

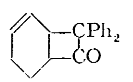
$$CHMe{:}CH\cdot CH{:}CH\cdot CO_2H \ (XVI) \longrightarrow CH_2Me\cdot CH{:}CH\cdot CH_2\cdot CO_2H \text{ and } CHMe{:}CH\cdot CH_2\cdot CH_2\cdot CO_2H$$

Investigations into catalytic hydrogenation pioneered the study of selective hydrogenation (*J.*, 1932, 430; 1933, 687; 1934, 304, 1929, 1938) and drew attention to the change in additive mode from " ageing " of the catalyst. Finally additive studies of hypochlorous acid to ethylenic and butadienoid acids (*J.*, 1932, 2062, 2072) revealed the difference between hypochlorous acid, as a reagent for the ethylenic linkage *per se* which had no tendency to add *via* a carbonyl group, and hydrogen halides (cf. *J.*, 1931, 129), and permitted an assessment of the orienting influence of the carboxyl and the phenyl group (*J.*, 1933, 800, 962).

About this time Diels and Alder (*Annalen,* 1928, **460**, 98) published an interpretation of, and extended, the known reaction between benzoquinone and *cyclo*pentadiene. The significance of this reaction and the possibility of *cyclo*butane as well as *cyclo*hexene formation, corresponding to 1 : 2- and 1 : 4-dibromides, led Farmer to pursue the reaction of non-dividing addenda to conjugated systems. The Diels–Alder formula, in which the position of the double bond had been assumed, was verified. The exclusive attachment at the 1 : 4-carbon atoms to form (XVII) from hexatriene, to which bromine added at the 1 : 2- and the 1 : 6-position, was adroitly classified as configurational opportunism (*J.*, 1929, 897; *Ber.*, 1930, **63**, 360). This was later contrasted with the sole formation of a four-membered ring from diphenylketen to give (XVIII) from *cyclo*hexadiene (*J.*, 1938, 1925).

(XVII)



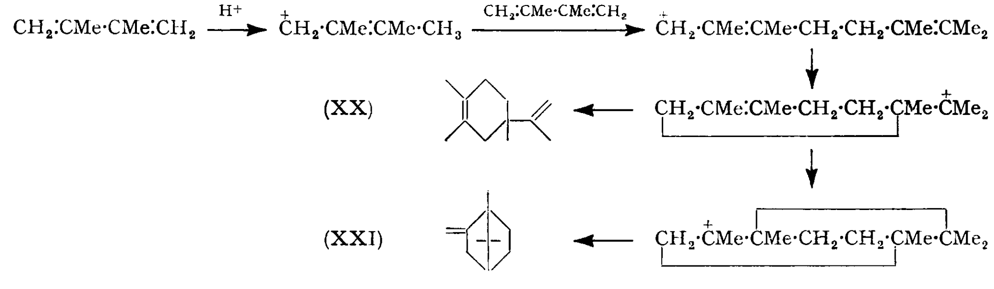


(XVIII)

The successful studies of the reaction of dividing and non-dividing addenda with unsaturated compounds prompted consideration of the self-addition of ethylenes and butadienes. The problem of polymerisation had for many years previously forced itself on Farmer, for it was a factor affecting starting materials, and substances like hexatriene had always to be generated from their precursors immediately before they were required. Tetramethylethylene (*J.*, 1937, 1039) was first selected since it contained no hydrogen capable of transfer. The dimeride (XIX)

$$CMe_2{:}CMe_2 \longrightarrow CHMe_2\cdot CHMe\cdot CH{:}CMe\cdot CMe_2 \quad (XIX)$$

proved, however, no exception to Whitmore's hypothesis (*Ind. Eng. Chem.*, 1934, **26**, 94). The polymerisation of dimethylbutadiene in acid medium (*J.*, 1938, 11, 287; 1940, 1169; *Trans. Faraday Soc.*, 1939, **35**, 1034) gave a dimer of the Diels–Alder type (XX) and a crystalline dicyclic dimer (XXI), and the formation of both dimers fitted Whitmore's proton-addition mechanism :



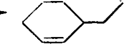
$$CH_2{:}CMe\cdot CMe{:}CH_2 \xrightarrow{H^+} \overset{+}{C}H_2\cdot CMe{:}CMe\cdot CH_3 \xrightarrow{CH_2:CMe\cdot CMe:CH_2} \overset{+}{C}H_2\cdot CMe{:}CMe\cdot CH_2\cdot CH_2\cdot CMe{:}CMe_2$$

$$(XX) \longleftarrow CH_2\cdot CMe{:}CMe\cdot CH_2\cdot CH_2\cdot CMe\cdot \overset{+}{C}Me_2$$

$$(XXI) \longleftarrow CH_2\cdot \overset{+}{C}Me\cdot CMe\cdot CH_2\cdot CH_2\cdot CMe\cdot CMe_2$$

The dimerisation of the unconjugated penta-1 : 4-diene (*J.*, 1940, 1176), which was the system occurring in several vegetable oils as well as in most glycerides from fish oils, gave some 4-allyl-3-methyl*cyclo*hexene (XXII) ; and the formation of this was explained by the prior isomerisation of one pentadiene molecule, but a hint is given that a free-radical mechanism could not be excluded.

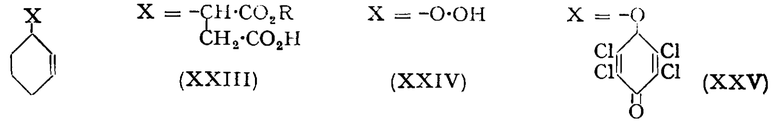
$$CH_2{:}CH\cdot CH_2\cdot CH{:}CH_2 \longrightarrow CH_2{:}CH\cdot CH{:}CHMe \xrightarrow{CH_2:CH\cdot CH_2\cdot CH:CH_2}$$



(XXII)

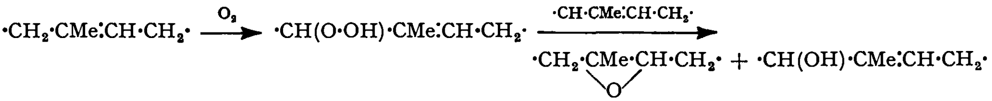
The study of the heat-polymerisation of methyl sorbate (*J.*, 1940, 1339) revealed the addition of the $\cdot CH{:}CH\cdot CO\cdot$ group of one reacting molecule across the terminals of the other diene system in both possible directions. A strictly polar mechanism would have implied two polarisations in opposite directions, which Farmer rejected in favour of a free-radical mechanism.

The concept of free radicals was now applied to autoxidation, and a mass of accumulated data and seemingly conflicting views on the structure and reactions of peroxides of simple olefins was systematically marshalled and carefully tested (*J.*, 1942, 121). Farmer was greatly stimulated by the observation that the peroxide of *cyclo*hexene was the hydroperoxide (Criegee, Pibz, and Flygare, *Ber.*, 1939, **72**, 1799) and realised that this would open up a new chapter in olefin chemistry. He drew attention (*Trans. Faraday Soc.*, 1942, **38**, 341) to the α-methylenic activity in olefinic and polyolefinic systems and the known reactions of *cyclo*hexene with maleic esters, oxygen, and tetrachlorobenzoquinone to form (XXIII), (XXIV), and (XXV) respectively; he



(XXIII) (XXIV) (XXV)

correlated these reactions with the dehydrating action of lead tetra-acetate and selenium dioxide. Farmer advanced reaction mechanisms for autoxidation and double-bond displacement (*ibid.*, pp. 348, 356), and extended the concept of α-methylenic reactivity in olefinic systems (*J.*, 1942, 139, 185). The oxidation of polyisoprenes by gaseous oxygen under ultra-violet radiation was shown to be first the formation of hydroperoxide groups on the α-methylenic carbon atoms and then autoxidation by the reaction of the hydroperoxide at the double bond to form epoxides and even to effect scission :



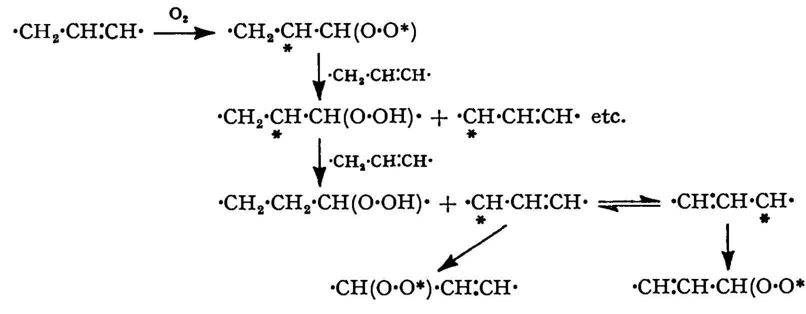
$$\cdot CH_2\cdot CMe{:}CH\cdot CH_2\cdot \xrightarrow{O_2} \cdot CH(O\cdot OH)\cdot CMe{:}CH\cdot CH_2\cdot \xrightarrow{\cdot CH\cdot CMe:CH\cdot CH_2\cdot} \cdot CH_2\cdot \underbrace{CMe\cdot CH}_{O}\cdot CH_2\cdot + \cdot CH(OH)\cdot CMe{:}CH\cdot CH_2\cdot$$

The possible extension of this concept to the interpretation of Ostromislensky's vulcanisation of rubber (*J. Russ. Phys. Chem. Soc.*, 1915, **47**, 1885) by dibenzoyl peroxide, which was known to form free radicals (Hey and Waters, *Chem. Reviews*, 1937, **21**, 169), resulted in the study (*J.*, 1942, 513) of the reaction of dibenzoyl peroxide on *cyclo*hexene. The findings led to the conclusion that the reaction of dibenzoyl peroxide on rubber resulted in the attachment of the benzoate groups mainly at the α-methylenic carbons to form

$$\cdot CH(OBz)\cdot CMe{:}CH\cdot CH_2\cdot CH(OBz)\cdot CMe{:}CH\cdot CH_2\cdot$$

and that the free radicals from the decomposing peroxide initiated the cross linking which could be continued by chain reaction (cf. Melville, *J.*, 1941, 414). The concept was developed to explain the effective vulcanisation by tetramethylthiuram disulphide, $(CHMe_2\cdot CS\cdot S)_2$, which is a close sulphur analogue of dibenzoyl peroxide. The mode of action of vulcanising accelerators had never previously been determined and it seemed likely that the effectiveness of at least some of them was due to this capacity to yield free radicals.

To account for the energy requirements (at least 80 kcal.) necessary for the removal of α-methylenic hydrogen, Farmer (*Trans. Faraday Soc.*, 1946, **42**, 229) envisaged that oxygen attacked initially a few olefinic molecules additively at the double bond and that oxygenation then continued substitutively by chain reactions. The resonance in the radical three-carbon



$$\cdot CH_2\cdot CH{:}CH\cdot \xrightarrow{O_2} \cdot CH_2\cdot \underset{*}{C}H\cdot CH(O\cdot O*)$$
$$\downarrow \cdot CH_2\cdot CH{:}CH\cdot$$
$$\cdot CH_2\cdot \underset{*}{C}H\cdot CH(O\cdot OH)\cdot + \cdot \underset{*}{C}H\cdot CH{:}CH\cdot \text{ etc.}$$
$$\downarrow \cdot CH_2\cdot CH{:}CH\cdot$$
$$\cdot CH_2\cdot CH_2\cdot CH(O\cdot OH)\cdot + \cdot \underset{*}{C}H\cdot CH{:}CH\cdot \rightleftharpoons \cdot CH{:}CH\cdot \underset{*}{C}H\cdot$$
$$\swarrow \qquad\qquad \downarrow$$
$$\cdot CH(O\cdot O*)\cdot CH{:}CH\cdot \qquad \cdot CH{:}CH\cdot CH(O\cdot O*)\cdot$$

systems would result in pairs of isomeric peroxides from mono-olefins and so accounted for his two forms, (XXVI) and (XXVII), of methyl oleate peroxide (*J.*, 1943, 119). The operation of this mechanism in the methylene-interrupted conjugation, ·C:C·C·C:C· (cf. Farmer *et al.*, *J.*, 1943, 122, 125, 541; 1946, 10), would give extensive rearrangement of the double-bond system to produce conjugated forms which would then pass to the production of viscous polymeric material. In the non-aromatic conjugated dienes and polyenes the initial addition was considered to be followed by linking up, the minor transient 1 : 2-peroxide conceivably accounting for the ready and unpreventable chain-scission, and the major 1 : 4-addition product giving polymeric products.

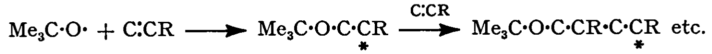
$$CH_3\cdot[CH_2]_7\cdot CH{:}CH\cdot CH(O\cdot OH)\cdot[CH_2]_6\cdot CO_2H \quad \text{(XXVI)}$$

$$CH_3\cdot[CH_2]_6\cdot CH(O\cdot OH)\cdot CH{:}CH\cdot[CH_2]_7\cdot CO_2H \quad \text{(XXVII)}$$

The concept of radical mechanisms led to the use of the action of di-*tert.*-butyl peroxide as a catalyst (*J.*, 1951, 131, 142, 149). Non-vinylic olefins and alkylbenzenes formed dehydropolymerisation products,

$$2Me_3C\cdot O\cdot + 2\cdot CH_2\cdot C{:}C\cdot \longrightarrow 2Me_3C\cdot OH + \cdot C{:}C\cdot CH{:}CH\cdot C{:}C\cdot$$

whilst vinylic (Δ^1-)olefins also underwent additive polymerisation initiated by radicals :



$$Me_3C\cdot O\cdot + C{:}CR \longrightarrow Me_3C\cdot O\cdot C\cdot\underset{*}{CR} \xrightarrow{C:CR} Me_3C\cdot O\cdot C\cdot CR\cdot C\cdot\underset{*}{CR} \text{ etc.}$$

The extension of this study to short isoprene chains and natural rubber established peroxide vulcanisation as a dehydro-cross-linking of carbon chains by carbon–carbon bonds as distinct from sulphur-bridge cross-linking of these chains; and the tensile strength of the product paralleled Gee's findings (*J. Polymer Sci.*, 1947, **2**, 451) for rubber–sulphur vulcanisates. It is significant, however, that the operation was accompanied by scanty incorporation of the *tert.*-butoxy-radicals into the rubber in sharp contrast to the much greater, and hence wasteful, combination of the benzoyloxy-radicals.

It will correctly appear that Farmer's main interests were essentially concerned with reaction mechanisms. He made, however, a brief excursion into synthetic chemistry and with equal success. In connection with the investigation of rubber it was necessary to obtain open-chain polyisoprenes of low molecular weight with a uniform head-to-tail arrangement. Following Ruzicka's procedure for building polyterpene alcohols Farmer (*J.*, 1942, 116) synthesised dihydrofarnesene, which represents the hydrogen-stabilised tri-isoprene member of the rubber series. This was followed by the successful joining of geranylacetone with the

$$Ger\cdot OH \longrightarrow GerCl \longrightarrow Ger\cdot CH_2\cdot CO\cdot CH_3 \longrightarrow Ger\cdot CH_2\cdot CMe(OH)\cdot CH_2\cdot CH_3$$

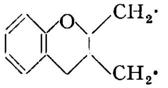
$$Ger = CH_3\cdot CMe{:}CH\cdot CH_2\cdot CH_2\cdot CMe{:}CH\cdot CH_2\cdot$$

Grignard reagent from 1 : 4-dibromobutane, to give a C_{30} glycol (XXVIII) which readily gave hexahydrochlorides identical with those from squalene and from which squalene could be regenerated. Thus he successfully accomplished a new synthesis of squalene and hydrocarbons of the squalene type.

$$2Ger\cdot CH_2\cdot CO\cdot CH_3 + BrMg\cdot[CH_2]\cdot MgBr \longrightarrow Ger.CH_2\cdot CMe(OH)\cdot[CH_2]_4\cdot CMe(OH)\cdot CH_2\cdot Ger$$

(XXVIII)

It seems appropriate to mention, in conclusion, the benefits which seemed to accrue by the close association of Farmer's Organic School with the studies in physical chemistry under Dr. Gee at the B.R.P.R.A. The fundamental concepts established in these laboratories did much to explain many phenomena which were previously obscure, and led, principally in collaboration with Dr. G. F. Bloomfield, to valuable contributions to the modification of rubber by such methods as autoxidation and chlorination (*J. Soc. Chem. Ind.*, 1934, **53**, 43T, 46T, 121T; 1935, **54**, 125T, 266; *Trans. Inst. Rubber Ind.*, 1940, **16**, 69; 1941, **16**, 260, 276). An applied study of some interest was the union of phenol–formaldehyde condensation products ("Novolaks") with the ethylene units in rubber to form chroman rings (XXIX), which could be cross-linked with hexamethylenetetramine to form a resin with some unique properties (*J.*, 1943, 472; *Endeavour*, 1944, **3**, 72).



(XXIX)

In the main, however, Farmer worked on model substances, because he early recognised the insuperable difficulty of working with materials such as rubber when no clue at all existed as to reaction mechanisms. However, he encouraged members of his team to work with more complex substances and these studies are to-day being continued.

Frank L. Warren.

WILLIAM GOODWIN.

1873—1953.

DR. WILLIAM GOODWIN died at his home at Wye, Kent, on December 30th, 1953.

Born in Macclesfield, Cheshire, on November 8th, 1873, he received his early education at the King Edward VI Modern Grammar School, Macclesfield (1881—1889), and Owens College, Manchester (1889—1894). After spending the next four years in analytical posts in Glasgow and Manchester, Goodwin went as Research Assistant to Professor Senier at Queen's College, Galway. From here he was awarded an 1851 Exhibition Scholarship which enabled him to study in Germany under Professor Tollens at Göttingen, and at the Laboratory for Vegetable Physiology in Paris where he worked in the field of sugar chemistry under Professor Macquenne. Goodwin then returned, first to Manchester to complete his Bachelor's degree and to carry out research in organic chemistry under Professor W. H. Perkin, jun., and then to Göttingen where he was awarded the Ph.D. degree in 1907 for a thesis entitled, " Über einige Ketone der Terpenreihe," this work having been supervised by Professor O. Wallach.

His long career in agricultural chemistry then began. After a few months as lecturer at Harper Adams College, he was appointed in 1907 to succeed Sir John Russell as head of the Chemistry Department at Wye College, Kent. Four years later he became principal of the Midland Agricultural College, Nottingham, a post which he held for eleven years; in 1922 he returned to Wye College as advisory chemist, where he remained until his retirement in 1938.

Although Goodwin became well known for his advisory work, as an examiner, and for his researches in many branches of agricultural chemistry, he always valued greatly the thorough training he had received as an organic chemist. Amongst his earlier published works are papers in the *Journal* with W. H. Perkin, jun., on such subjects as, " β-dimethylglutaric acid," " *cis*- and *trans*-hexahydro*ortho*toluic acids," " some derivatives of propionic acid, of acrylic acid, and of glutaric acid," and " the reduction of *iso*phthalic acid." Other papers, bearing also the names of Senier, Tollens, and Macquenne appear in the *Journal, Bull. Soc. chim.*, and *Berichte*. Goodwin, however, must be regarded above all as one of the leading influences in Britain in the development of the science of crop protection. The value of the work which he and his associates carried out over many years both on fundamental and applied aspects of insecticidal and fungicidal research will always be recognised. During this period he published many papers in *J. Agric. Sci.*, *Ann. Appl. Biol.*, and *J. S.E. Agric. Coll., Wye*, with Professor E. S. Salmon, Dr. H. Martin, and others.

Although during the last years of his life Dr. Goodwin was seriously handicapped by spinal trouble, his kind and cheerful personality was always evident and he maintained a keen interest in scientific developments, particularly in agricultural chemistry, to the end. He was a member of many learned societies and was a Fellow of the Chemical Society for fifty-seven years.

We extend our sympathy to his widow and two daughters.

R. L. WAIN.