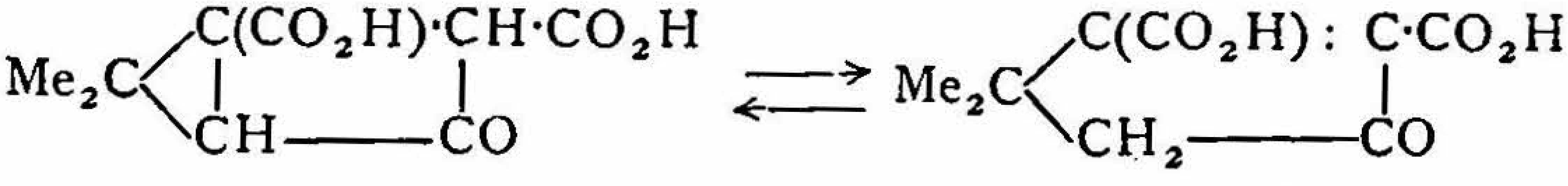
STUDIES IN BRIDGE FORMATION

PART IV. TAUTOMERISM IN *iso*PHORONE

By P. S. Mayuranathan.

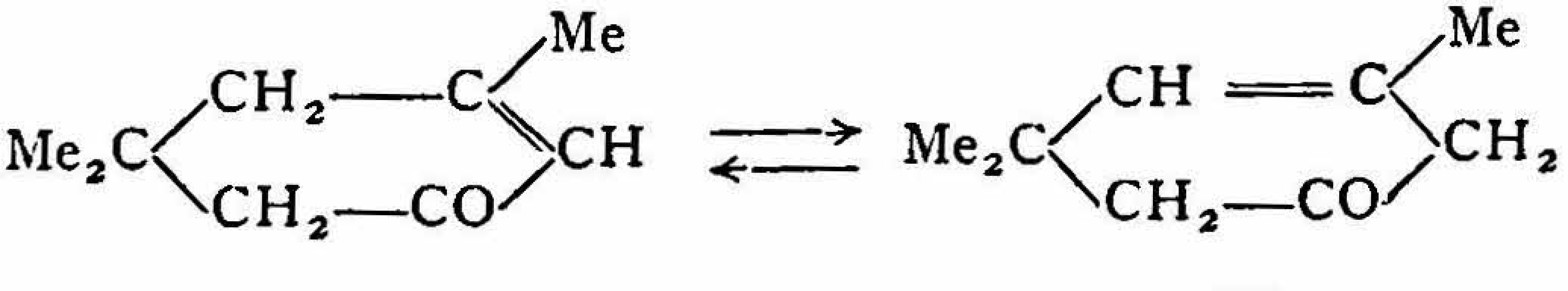
In their opening paper on intra-annular tautomerism (*J. C. S.*, 1922, **121**, 128) Farmer, Ingold, and Thorpe have shown that dimethyldi*cyclo*pentanonedicarboxylic acid which by synthesis would possess structure (I) behaves also as though it had the unsaturated structure (II).



I II

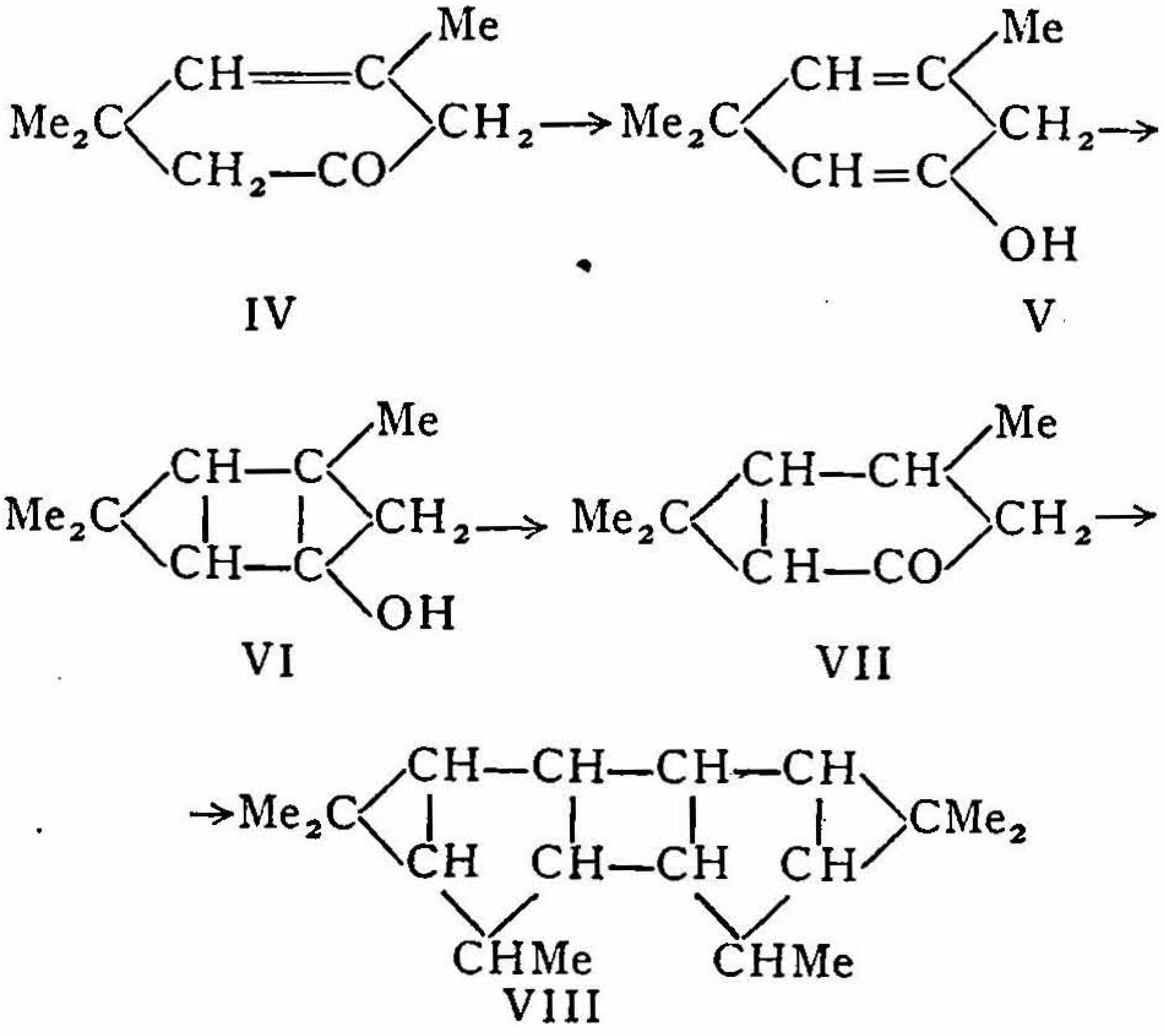
An attempt is made in this paper to trace a similar phenomenon in the molecule of *iso*phorone (III).

Two isomeric forms of *iso*phorone (III) and (IV) have been discovered by Bredt and Rubel (*Annalen*, 1898, **299**, 160), and Kerp and Muller (*ibid.*, 1898, **299**, 193) depending on the shift of a double bond in the molecule.



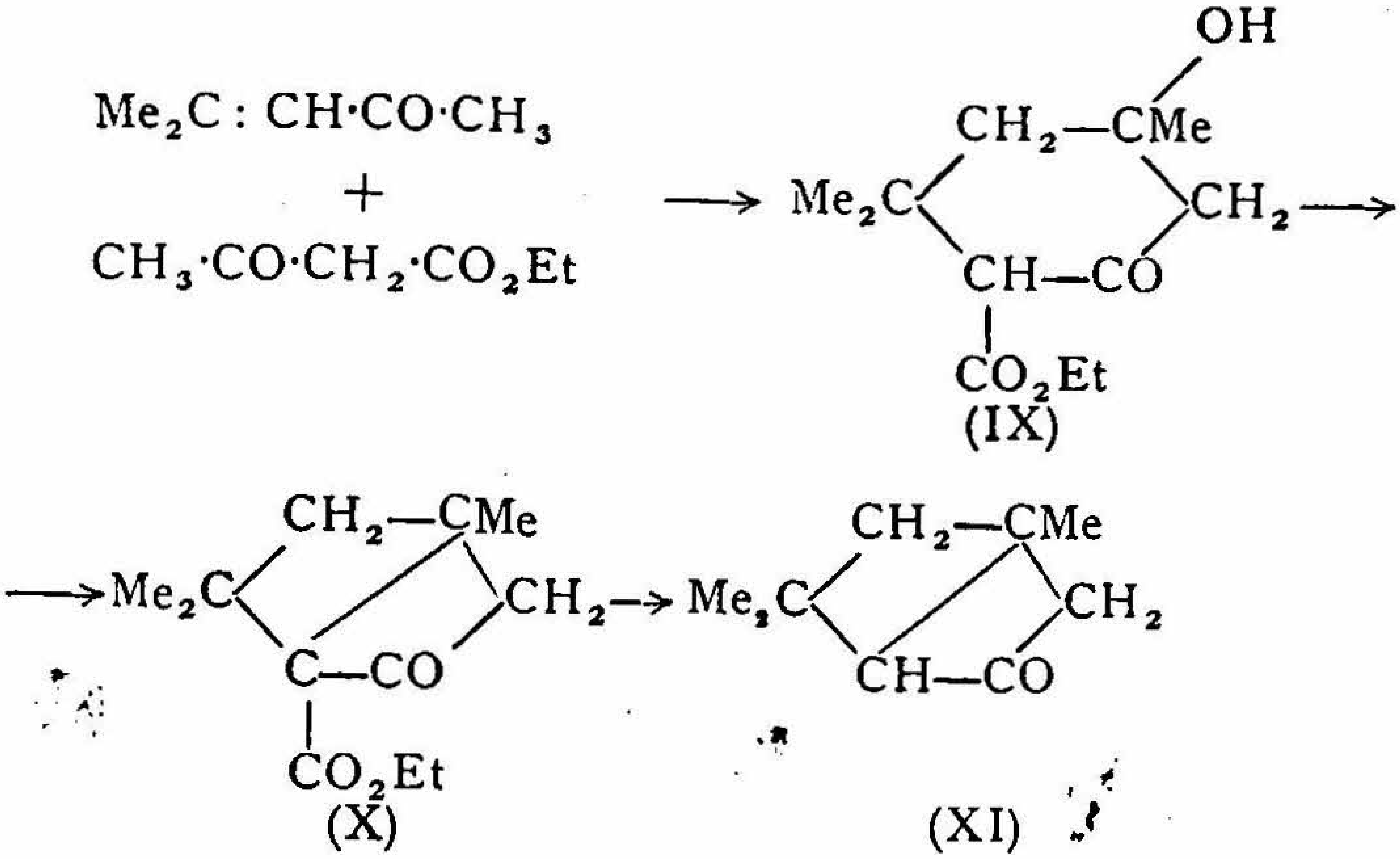
III IV

Lately, Baker (*J.C.S.*, 1926, 626) has ingeniously applied the principle of intra-annular tautomerism to the molecule of *iso*phorone and in accordance with the scheme outlined below claims to have obtained, on reducing the ketone by Clemmensen's method, a hydrocarbon, $C_{18}H_{28}$ (VIII), m.p. 112°, possessing two *cyclo*propane bridged bonds. Proof for the constitution of (VIII) was that on oxidation with alkaline permanganate it gave caronic acid. On attempting to reproduce these reactions the author was unable to obtain the solid hydrocarbon (VIII), the final product being a liquid with the formula $C_{18}H_{32}$. All attempts at its oxidation to caronic acid proved ineffective showing that the *cyclo*propane bridged bonds in (VIII) have been saturated; the possibility of the *cyclo*butane ring opening up is also unlikely because of the consequent formation of a ten-membered ring.



IV V VI VII VIII

Of the two known syntheses of *iso*phorone one is due to Bredt and Rubel (*loc. cit.*) by condensation of three molecules of acetone, and the other to Knoevenagel and Fischer (*Annalen*, 1897, **297**, 185) from mesityl oxide and acetoacetic ester. The latter synthesis is analogous to that of the bridged *cyclo*hexenones (Part II and III) and on *a priori* considerations it appeared possible that during formation (the dehydration perhaps enhanced by the actual presence of a hydroxyl *para* to the reactive hydrogen atom) it should have passed through a bridged phase (XI). This demands less strain on the molecule than the double bridged phase (VI) proposed by Baker (*loc. cit.*). The mechanism of the formation of *iso*phorone can be represented by the following scheme:



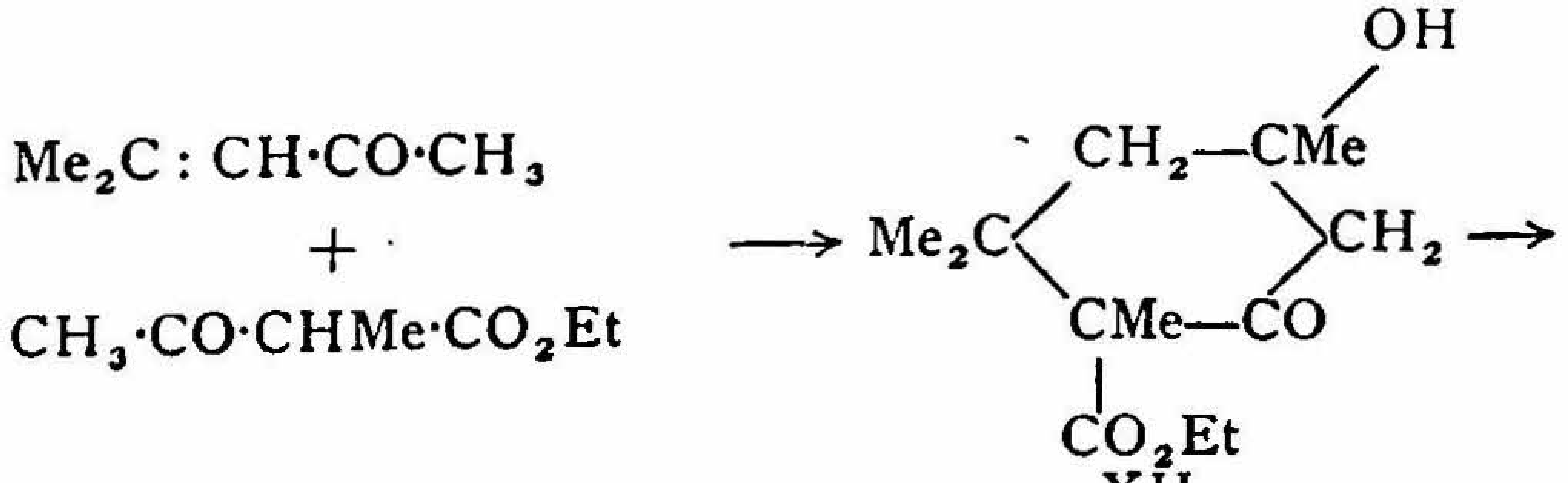
(IX)

(X)

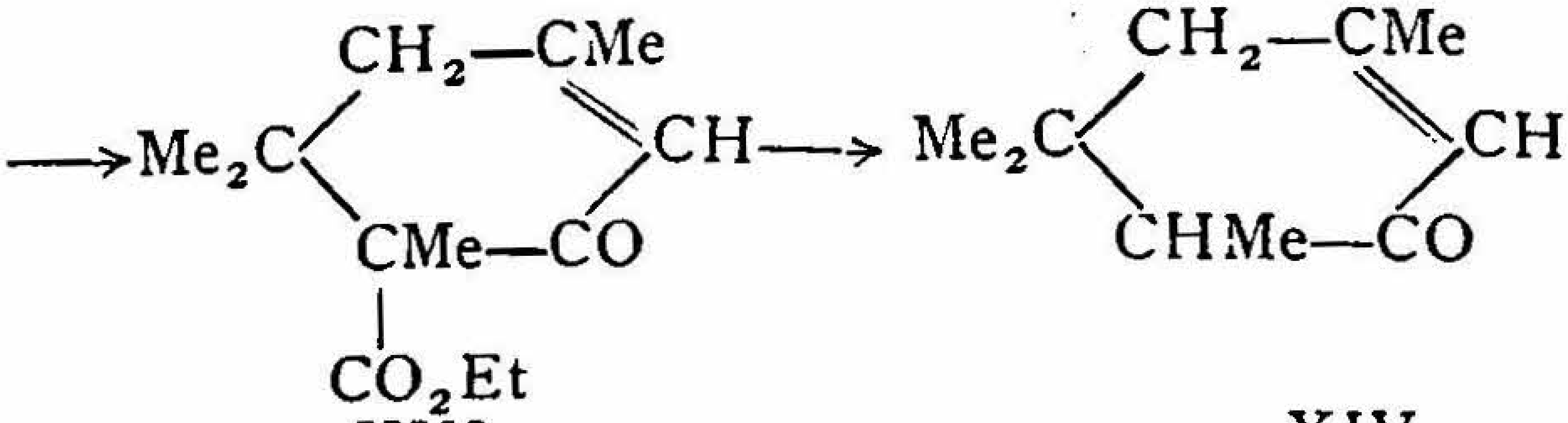
(XI)

The hydroxy ester (IX) as soon as it is formed gets dehydrated by sodium ethoxide to the bridged ester (X) accounting for the non-isolation of the former and the alcoholic sodium hydroxide incidentally formed hydrolyses ester (X) to the ketone (XI). The constitution of the dehydrated ester is ambiguous as it can have either a bridged or a double bonded form according as dehydration takes place across or along the ring, but if preference be given to dehydration involving the reactive methylene group, the resulting ketone should have a bridged structure. The dehydrated ester, however, on methylation gives (XIII), probably due to reactivity acquired through the wandering of a hydrogen atom.

The main product obtained by condensing mesityl oxide with methyl acetoacetic ester is the ester (XII): this contrast with the foregoing experiment establishes that a decisive factor in dehydration is the hydrogen atom *para* to the hydroxyl rather than the less reactive one attached to the ketomethylene group.



XII



XIII XIV

EXPERIMENTAL

Clemmensen reduction of isophorone *to the hydrocarbon* $C_{18}H_{32}$.—To a mixture of *isophorone* (60 g.) and amalgamated zinc (300 g.) in a litre flask was gradually added concentrated hydrochloric acid (540 c.c.) and the mixture boiled under reflux slowly for 6 hours until all the zinc had reacted. The diluted solution on ether extraction gave a viscous oil (52 g.) which on steam distillation gave no solid hydrocarbon. On repeating the experiment several times a camphoraceous oil (4 g.) was collected which distilled at 102°/5 mm. The original oil on distillation gave the same hydrocarbon, yield 5 per cent. (Found: C, 86.5; H, 13.2; *M*, 246. $C_{18}H_{32}$ requires C, 87.1; H, 12.9 per cent.; *M*, 248).

Formation of isophorone *ester* (X) *and* isophorone (III).—A mixture of mesityl oxide (100 g.) and acetoacetic ester (133 g.) was added gradually under ice-cooling to a solution of sodium (23 g.) in alcohol (300 c.c.) and kept in the ice-chest for 10 days and then boiled under reflux for 4 hours, when carbon dioxide was profusely evolved. The alcohol-free residue was acidified and extracted with ether when a colourless oil (III) was obtained, b.p. 135°/20 mm., yield 75 per cent., $d^{24°}$ 0·9461, $n_D^{24°}$ 1·4752, $[R_L]_D$ 41·10 (calc.: 41.11) (Found: C, 78.0; H, 14.2. $C_9H_{14}O$ requires C, 78.3; H. 14.0 per cent.). The *semicarbazone* had m.p. 196°.

When refluxing was omitted and the mixture neutralised by passing carbon dioxide, an appreciable quantity (yield, 5 per cent.) of colourless oil distilled at 162°/20 mm. (X), $d_{25°}$ 1·065, $n_D^{25°}$ 1·4788 $[R_L]_D$ 55.91 (calc. 54.88) (Found: C, 68.5; H, 8.9; *M*, 210. $C_{12}H_{18}O_3$ requires C, 68.6; H. 8.6 per cent.; *M*, 210). The *semicarbazone* had m.p. 218° (decomp.) (Found: N, 15.7. $C_{13}H_{21}O_3N_3$ requires N, 15.7 per cent.).

Methylation of ester (X) *to* (XIII).—To sodium (2.3 g.) in alcohol (30 c.c.) were added ester (X) (20 g.) and methyl iodide (15 g.) and the contents boiled under reflux for 4 hours. The resulting ester distilled at 175°/20 mm., and was identified with (XIII).

Formation of ketone (XIV) *and esters* (XIII) *and* (XII).—A mixture of mesityl oxide (100 g.) and methyl acetoacetic ester (147 g.) was added to sodium (23 g.) dissolved in alcohol (300 c.c.) and kept in the ice-chest for 10 days. It was found necessary to reflux the mixture for 6 hours to complete the reaction. On working up the product and distilling, three fractions were collected; fraction (i) was a light yellow oil (15 g.) b.p. 143°/20 mm., $d^{23\cdot5^\circ}$ 09616, $n_D^{23\cdot5^\circ}$ 1·4900, $[{}^{R}L]_D$ 45·69 (calc.: 45.74) (Found: C, 78.8; H, 10.8. $C_{10}H_{16}O$ requires C, 78.9; H, 10.5 per cent.). The *semicarbazone* melted at 200° (Found: N, 19.4. $C_{11}H_{19}ON_3$ requires N, 20 per cent.); fraction (ii) (20 g.) distilled at 175°/20 mm., d^{24° 1·1151, $n_D^{24^\circ}$ 1·5205, $[{}^{R}L]_D$ 61·16 (calc.: 61.23) (Found: C, 69.5; H, 9.2. $C_{13}H_{20}O_3$ (XIII) requires C, 69.7; H, 8.9 per cent.). The *semicarbazone* had m.p. 235° (decomp.) (Found: N, 14.5. $C_{14}H_{23}O_3N_3$ requires N, 14.9 per cent.). Fraction (iii) (XII) (136 g.) distilled at 196°/20 mm. as a thick yellow oil (Found: C, 64.2; H, 9.4. $C_{13}H_{22}O_4$ requires C, 64.4; H, 9.1 per cent.).

In conclusion the author wishes to express his grateful thanks to Dr. P. C. Guha, D.Sc., and Sir Martin Forster, F.R.S., for their kind interest and helpful suggestions in this work.

Department of Organic Chemistry,
Indian Institute of Science,
Bangalore.

[Accepted 21-7-1933.]

PRINTED AND PUBLISHED
BY V. M. PHILIP AT THE DIOCESAN PRESS,
POST BOX 455, MADRAS—1934. C8999.