

might at least partly explain the apparent increase of stress coefficient with fetch which was found. The effect of wave set-up was certainly not appreciated in 1955 when these results were published, but a recent paper by Longuet-Higgins and Stewart has shown that waves only increase the set-up when their height is limited by breaking, as otherwise the effect is reversed and they reduce the set-up. The recording apparatus in this case was laid in about 2-ft. water depth so the mean wave height should be about 3 ft. for continual breaking, but this value was only very rarely attained during the course of the measurements. The effect of wave set-up is very important nevertheless, and the author rightly points out that tilt experiments should be so designed that this effect is a minimum.

These are all minor points of criticism, and the book is an excellent exposition of the subject and will, I hope, inspire a more widespread study of it. It should certainly be in the library of every oceanographer and every meteorologist.

J. DARBYSHIRE

LIQUID-PHASE OXIDATION OF HYDROCARBONS

The Oxidation of Hydrocarbons in the Liquid Phase

Edited by N. M. Emanuel. Translated from the Russian by K. R. Dobson and B. J. Hazzard. Pp. xv+407. (Oxford, London and New York: Pergamon Press, 1965.) 140s.

THE oxidation of hydrocarbons has been the subject of intense investigation for a long time, and particularly so during the past 20–30 years. Oxidation in general is of paramount importance, not only in chemistry, but also in biology and in other related sciences. The oxidation of hydrocarbons is mainly of interest in chemistry, both because of its academic and industrial aspects. In the organic chemical industry oxidation reactions of hydrocarbons play a very important part and great developments are still occurring in this field.

This book deals with certain aspects of the oxidation of hydrocarbons in the liquid phase with gaseous oxygen as oxidant. Even early workers found that the chemistry of these reactions is complex, and it is not surprising, therefore, that progress has been slow. It was established in the early 'thirties that these oxidations proceed by a chain mechanism and show the complex characteristics of reactions of this type. A first real understanding of the mechanism, although confined to the initial stage of the reaction only, was obtained as a result of the work of Criegee and Hock in Germany and of Farmer and Bolland in Britain. This work revealed the central position of hydroperoxides and hydroperoxy radicals in the reaction scheme and led to a mechanism for the first stages of the oxidation of olefines, paraffins, *cycloolefines* and alkylaromatics which has been generally accepted.

However, if oxidation is carried on to conversions greater than a few per cent, complications arise which greatly influence the course of the reaction. This characteristic feature of oxidation reactions is very important because the industrial processes operate in this range of conversion which extends from about 2 to 30 per cent.

During the past ten years or so the Russian workers, whose collective effort is represented in the book under review, have been concerned with this problem and have made important and far-reaching advances in the understanding of the reaction mechanism at the later stages of oxidation. One must be grateful to N. M. Emanuel for having assembled, as editor, his own work and that of Knorre, Maizus, Denisov, Bashkirov, to name only a few, in this book, which has now been translated from the Russian by K. R. Dobson and B. J. Hazzard, and edited by J. D. Hopton.

Apart from this group of papers dealing mainly with the mechanism of the oxidation reaction, the book also

contains a collection of papers which are concerned with the technical and more phenomenological, as distinct from the detailed mechanistic, aspects of the liquid-phase oxidation of hydrocarbons.

Discussing first the former group of papers, Emanuel and his colleagues have made good use of the theory of gas-phase oxidation reactions developed by Semenov. Particularly, the concept of the degenerate chain branching reaction has proved very useful in explaining many features of the liquid-phase oxidation at the larger extent of reaction. In this case degenerate chain branching is due to the decomposition of the hydroperoxides formed as primary products of the reaction. This is the main factor causing the characteristic self-acceleration of the reaction. In addition, other changes in the reaction mechanism occur at this stage. For example, Denisov has shown that the original chain carriers are replaced by others derived from the oxygenated products. The new chain carriers may be less reactive than the original ones and thus slow up chain propagation, resulting in a retardation of the overall reaction.

These complex conditions have been analysed in a quantitative manner, which leads to an explanation of many features of the oxidation reaction at higher conversions. Other characteristics such as the influence of inhibitors of various types also agree with the reaction scheme. These are important achievements well brought out in the group of papers on mechanism. The only criticism I have is a certain obscurity and even incompleteness in the definition and explanation of the symbols used. As a result it is sometimes unnecessarily difficult to follow the mathematical derivations.

As for the group of technological papers, they are concerned with a variety of industrial aspects of hydrocarbon oxidation such as the oxidation of paraffins to fatty acids, *cyclohexane* to *cyclohexanone* and *cyclohexanol*, the oxidation of fuels under storage and the inhibition of this oxidation.

None of the work reported in the latter group of papers is radically new; but it is of great value to have collected in one volume this information, which is otherwise scattered throughout the literature and patent specifications. It should be of particular value to anyone who wishes to orient himself in an unfamiliar field.

This book clearly is to be welcomed and recommended to anybody interested in the oxidation of hydrocarbons in the liquid phase.

The translation is good and readable, and the publishers are to be congratulated for having made the book available to the many who cannot read it in the original language.

H. STEINER

STATISTICS FOR NON-MATHEMATICIANS

Statistical Inference

By Prof. Jerome C. R. Li. Vol. 1: Pp. xix + 658. Vol. 2: Pp. xiv + 575. (Ann Arbor: Edwards Brothers, Inc., 1964.) 10 dollars each volume.

THE first volume of this very large work has the sub-title *A Non-Mathematical Exposition of the Theory of Statistics* and is a revised edition of the author's earlier work *Introduction to Statistical Inference*. The second volume has the sub-title *The Multiple Regression and its Ramifications*, and is a new book. A brief listing of most of the chapter headings will give a fair idea of the contents. Volume 1: descriptive statistics, normal distribution, sample mean, test of hypothesis, χ^2 -, t - and F -distributions, difference between sample means, confidence interval, one-way classification, randomized blocks, linear regression, factorial experiment, analysis of covariance, binomial and multi-nomial populations, transformations, distribution-free methods. Volume 2: matrix algebra, multiple regression, curvilinear regression,