of the causal organism of Malta fever (*Brucella melitensis*) is said to be Sir Robert Bruce and not Sir David. Here is a possible confusion with Robert the Bruce, whose field work, so tradition relates, was concerned with fundamental studies on the habits of the Arachnidæ and not with micro-organisms!

Some of the historical notes are most entertaining and do much to enliven the pages of Prof. Birkeland's volume. One feels, however, that the author is happiest in the concluding chapters of his book, dealing with microbiology of food, milk, water, sewage and soils. The chapters on microbiology and water and on sewage reach a high standard of clarity and excellence. R. ST. JOHN-BROOKS.

ENGINE RESEARCH

The Chemical Background for Engine Research

Edited by R. E. Burk and Oliver Grummitt. (Frontiers in Chemistry, Vol. 2, published under the auspices of Western Reserve University.) Pp. xii+297. (New York: Interscience Publishers, Inc.; London: Imperia Book Co., Ltd., 1943.)

IN recent years increasing attention has been paid to ways and means of keeping students and industrial scientific workers abreast of advances in those branches of fundamental research which have an application to their work; and facilities are now available which, although still imperfect, have gone a long way to meet the requirement. The publication of classified abstracts, for example, is an essential service to this end, the value of which is unquestioned. In addition, the compilation of progress reports and special monographs affords a means of supplementing the abstracts by periodic critical reviews of contemporary work. It is thus possible, in most instances, to obtain a reasonably comprehensive account of the present state of knowledge in any particular branch of science without a laborious search through the literature.

The volume under review represents a contribution to the latter category of publications. It originates in a project sponsored by Western Reserve University for bringing graduates into personal touch with groups of distinguished workers in selected fields, to hear first-hand of the researches in progress and of the directions in which significant advances are being made. The lectures given by the various groups are afterwards published in a series entitled "Frontiers in Chemistry". Two volumes have appeared so far entitled, respectively, "The Chemistry of Large Molecules" and "The Chemical Background of Engine Research".

The six contributors to the latter volume, E. F. Fiock, F. D. Rossini, F. C. Whitmore, G. von Elbe, B. Lewis and O. Beeck, are well known in Great Britain for their pioneer work on the physical and chemical properties of hydrocarbon fuels generally and on the internal combustion engine, and their considered views on engine research therefore constitute an important contribution to the literature of the subject. The scope of the lectures is comprehensive, and includes methods of synthesis of complex hydrocarbons, a clear summary of their combustion characteristics, recent theories of combustion, chemical thermodynamics of hydrocarbons and physico-chemical aspects of lubrication. To the student of combustion the lectures by Fiock, von Elbe and Lewis are of particular interest in that they assemble all the relevant experimental data relating to the oxidation of hydrogen and the simpler hydrocarbons and proceed to show how the observed phenomena may be fitted into a general theory of combustion. The result is not entirely satisfactory. Indeed, Fiock, in his second lecture, states ". . . it may truthfully be said that not a great deal is actually known of the highly complex mechanism by which the chemical energy latent in the combustible mixture is transformed into usable mechanical energy"; and the reader will probably come to the same conclusion.

The shortcomings of the theory, outlined in von Elbe's contribution, arise partly from the fact that in no single instance have the combustion characteristics of a hydrocarbon been determined experimentally over the full range of reacting mixtures, and partly owing to a tendency to cling to the simple mechanical analogy which came into vogue in the early days of the atomic and kinetic theories.

In considering any mechanisms for combustion, it is necessary to distinguish clearly between ascertained fact and surmise. Experiment in general only gives information as to the identity of stabilized products which survive when a reacting medium is suddenly chilled; it gives no accurate data as to the instantaneous composition of the medium at any stage of the combustion. In consequence, kinetic data based upon chemical analysis or observations of changes in pressure are difficult to interpret save in the case of slow reactions between simple molecules. There is, however, strong evidence that combustion processes involve, in many instances, an orderly interchange of energy of a specific kind represented in the mechanical analogy by the links of chains, either single or branched; and to account for the kinetic data it is now customary to identify the chains with the formation of free radicals by the initial dissociation of the reacting molecules, and their subsequent interaction with other radicals, atoms or molecules in a series of elementary chemical reactions.

As to the composition or even the existence of free radicals in such circumstances, experiment tells us little. Indeed, von Elbe points out that in the case of any particular hydrocarbon "the reactions considered to be of consequence are selected because by means of the kinetic theory of gas reactions they yield equations which, after introducing certain numerical values, correctly describe the dependence of explosion limits and reaction rates on the experimental variables pressure, temperature, vessel diameter, mixture composition, and nature of the surface; and because no alternative, or at least no plausible alternative schemes yield the correct relation. There is no method known by which the individual chain-carrier reactions may be studied independent of each other".

It will be clear from the above that much exploratory work of a fundamental character yet remains to be done before a generally acceptable theory of combustion can be formulated.

In conclusion, it may be well to remove the impression that the lectures deal solely with the more recondite aspects of combustion theory. They have, in fact, a strong practical trend, and give adequate emphasis to experimental methods and to such important factors as engine 'knock' and lubrication. The book is well illustrated, and useful bibliographies are given by each contributor.

D. M. NEWITT.