The Chemistry of Powder and Explosives

COMPLETE IN ONE VOLUME

BY

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PREFACE

The present volume contains in one binding the whole contents of Volume I, first published in May, 1941, and the whole contents of Volume II which was published in March, 1943.

The book is primarily for chemists. The writing of it was commenced in order that a textbook might be available for the use of students in the course in powder and explosives which the author gave for about twenty years (nearly every year since the first World War) to fourth-year and graduate students of chemistry and of chemical engineering at the Massachusetts Institute of Technology. The writing of it has been completed while the nation is at war and while many chemists, not previously trained in powder and explosives, are at work preparing, studying, and testing these materials. The purpose of the book is to supply chemists with information concerning the modes of behavior of explosive substances and concerning the phenomena, both chemical and physical, which they exhibit. No effort has been made to describe the use of explosives in ammunition and in blasting beyond the minimum of description which is needed to make clear the modes of their behavior, and no account has been included of the chemical engineering aspects of their manufacture.

The book brings together much material which has never before been collected in one volume, and it sets down some of the facts in what are probably new relationships to one another, but it contains nothing which is not already known to those who are skilled either in chemistry or in the manufacture and use of explosives. It is elementary in the sense that it supplies a background of knowledge for the chemist who wishes to become an expert in any one of several technical branches.

The chapter on pyrotechnics has been made as full as possible. It contains much which will not be found in print elsewhere, but it limits its discussions to civil pyrotechnics—for several reasons. Civil pyrotechnics is a much broader subject than military pyrotechnics. Military pyrotechnic devices differ in no important respect from similar devices for civil and recreational

purposes. Their varieties are few. Artifices which are not now used for military purposes may some day be applied to the uses of war, and a broad knowledge of civil pyrotechnics plus an acquaintance with the military necessities will determine the applications.

Workers with explosives will perhaps think that I have included in the chapter on pyrotechnics too much material on the construction of fireworks pieces, but chemists, interested in the manner in which their substances behave, will be tempted to try their hands at making the artifices, and the fireworks makers, aware of the importance of these details, will probably think that the account of them is too meager.

The chapter on aromatic nitro compounds deals with the chemistry of a large and important class of explosive substances, among which TNT stands as the most important of the military high explosives, with tetryl second in importance, while the whole class includes substances which are used, or may be used, in shells, bombs, grenades, and other devices of war. The precise manner in which they are loaded, the amounts which are used, the details of the construction of the devices, etc., are known to those who are concerned with such matters. But the practices change. The principles of the use of the materials and the physical and chemical properties of the substances upon which the principles depend do not change—and they are the proper subject matter of the present book.

The aim of the book has been to describe as clearly and interestingly as possible and as fully as seemed profitable the modes of behavior, both physical and chemical, of explosive substances, whether these modes find practical application or not. Historical material has been included where it was thought that it contributed to this end, and it has not been included elsewhere or for any other reason. It is a fact that a knowledge of the history of ideas, of persons, or of things produces something of the same sympathetic understanding of them that living with them and working with them does.

I am indebted to many friends to whom I wish to make grateful acknowledgment of information, of pictures, and of criticism. Dr. C. G. Storm has read the entire manuscript and has made many helpful suggestions. Dr. Walter O. Snelling has read the chapter on aromatic nitro compounds, has kindly prepared the specimen to illustrate the Munroe effect, and has made the photo-

graphs from which the two figures are reproduced. Allen F. Clark of Bridgewater, Massachusetts, has read the chapter on pyrotechnics and has supplied many formulas and much other information. His brother, George J. J. Clark of Whitman, Massachusetts, has furnished several pictures of operations at the plant of the National Fireworks Company, while the *Boston Globe* with his consent has supplied others, and a third brother, Wallace Clark of Chicago, Illinois, has given information relative to the manufacture of Chinese firecrackers and has furnished the pictures which illustrate the process. George W. Weingart of New Orleans, Louisiana, has supplied information in his letters and has given permission to use material from his "Dictionary and Manual of Fireworks," and A. St. H. Brock of London, England, has given permission to quote from his "Pyrotechnics: The History and Art of Firework Making." I am indebted to Dr. E. Berl, to Dr. Émile Monnin Chamot, to the U. S. Bureau of Mines, to the Atlas Powder Company, to E. I. du Pont de Nemours and Company, Inc., to the Ensign-Bickford Company, to the Hercules Powder Company, to the Trojan Powder Company, and to the Western Cartridge Company for pictures; to the Williams and Wilkins Company of Baltimore for permission to cite and to quote from Symmes' translation of Naoúm's "Nitroglycerine and Nitroglycerine Explosives"; to Sir Isaac Pitman & Sons, Limited, of London, for permission to cite and to quote from MacDonald's "Historical Papers on Modern Explosives," published originally by Whittaker & Co., whose business this firm later took over, and to the *Journal of the American Chemical Society*, to *Industrial and Engineering Chemistry*, to the *Journal of Chemical Education*, to the *Journal of the Franklin Institute*, to *Army Ordnance*, to the U. S. Bureau of Mines, and to the University of Pennsylvania Press for permission to cite and to quote from their publications. My thanks are also due to Professor Warren K. Lewis who has read the proof of Volume I and to Dr. Joseph Ackerman, Jr., who has read the proof of Volume II.

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