

## CHARBONNIER ON EXTERIOR BALLISTICS

*Traité de Balistique Extérieure.* By P. Charbonnier. Volume II. *Problème Balistique Principal, Troisième Partie; Les Théories Balistiques.* Paris, Doin, Gauthier-Villars, 1927. 797 pp.

This volume follows Volume I, (of 637 pages, 1921) devoted to *Les Théorèmes Généraux de la Balistique*, and is to be succeeded by a third volume in rational ballistics concerning secondary ballistic problems. Volume I was divided into four books and this volume also is divided into four books numbered from five to eight as follows: Book V, Monomial Resistance; Book VI, Flat Fire; Book VII, Ballistic Series; Book VIII, The Calculation of Trajectories by Successive Arcs. From the Introduction to Volume I, one learns that three further volumes on ballistic science are planned, Volume IV, Experimental Exterior Ballistics, Volume V, History of Exterior Ballistics (with bibliography), Volume VI, Tables. The subject of interior ballistics, which differs considerably in its problems and methods, is not to be touched upon in this series.

The present undertaking is essentially a careful (save for numerous misprints) revision with amplification of the author's two volume work (*Balistique Extérieure Rationnelle*) of 1907. Not only is the subject treated throughout in greater detail, but additional carefully written chapters on newer methods have been introduced. In 1907, Charbonnier's work placed him as one of the conspicuous ballisticians of the world. Since that time he has been made a general in the French Army, and is here progressing with customary French lucidity upon the most ambitious text on ballistics ever undertaken. This should ensure respectful consideration from the few technical scientists seriously interested in ballistics.

Works on ballistics from the time of Bashforth, tend to have a curiously provincial air. They can hope to be of significance chiefly to artillery officers, who, however, seldom have the preparation, interest, or opportunity to study them. Most experimental work is kept in confidential army files. There is also a strong patriotic tendency toward nationalistic bias that army training and army contacts naturally accentuate. Most books on ballistics give the reader the impression that progress in the subject is practically confined to the compatriots or even to the friends of the author. This is noticeable even since the war. This book is no exception.

Ballistics is inherently a branch of engineering. Not only are there a distractingly large number of physical factors present in the problem, but the number of independent variables that are actually taken into account in firing is so large, and these variable factors are to a great extent so uncontrollable, that simple accurate formulas are universally regarded as out of the question. Rules based on the normal probability curve are used in actual field conditions, and the numerical tables upon which original computations are constructed are themselves obtained by statistical methods involving more or less arbitrary assumptions. The only methods used in

the past have been to relegate the less important variations to a secondary place (not to be ignored, but to be treated as linear differential perturbations) and to incorporate only the most important features into the fundamental differential equation for a trajectory. What this equation is, depends in part on the particular problem, but is in no case as simple today as it was before the World War. In the sense of "rational mechanics", there is no rational ballistics.

For ballistics, as for every other developing branch of engineering, there is a group of present-day problems involved on the one side in seeking to test present-day assumptions, and if possible to establish these on a rational basis, and on the other side in devising means for application of these accepted principles with an accuracy consistent with the data and yet with the greatest possible simplification concordant therewith.

An excellent survey of the history of ballistics, replete with illustrative comparisons, explicit data, and critical comments on physical assumptions, is given by the long classical work of C. Cranz. The only criticism is that despite supplementary notes in later editions, the work closes essentially with the period before the World War, which changed the perspective even on old problems.

This work of Charbonnier bids fair to be considerably more extensive than that of Cranz. Unfortunately it is subject to the same limitation that the author's point of view is that of 1914 and this is not relieved by the mere insertion of additional chapters on new methods. Unlike the work of Cranz, this book attempts to deal with what appears to be a non-existent subject. In open and deserved admiration of the secure position of rational mechanics (in which French writers from Laplace to Appell appear to surpass themselves) this army officer effectually divorces ballistics at this stage from its only logical bases, historical and physical. We meet, consequently, for at least the first seven hundred pages of this volume, a collection of mutually contradictory theories. These are given no historical justification and one cannot make comparisons among them since the author himself fails to compare their relative accuracy and withholds as yet all physical data from the reader in the effort to be strictly rational. It may be of interest to American readers that a condensed but just account (covering five pages) of American methods with reference to Major Moulton is found in the chapter, "Exposé de quelques méthodes de calcul."

Perhaps the most severe criticism of this book by Charbonnier (in view of its date of publication) is contained in his own words, à propos of the artificial solutions of Drach. "Les solutions, . . . , quelque intéressantes qu'elles soient, ne remplissent pas les deux conditions simultanées qu'exigent les balisticiens: 1° s'appliquer à une forme de la fonction  $F(v)$ , acceptable, c'est-à-dire suffisamment voisine de la fonction expérimentale de la résistance de l'air; 2° conduire, pour les autres éléments du mouvement à une solution formelle, susceptible d'être utilisée pour les applications numériques."

Possibly reference to future volumes of this projected series will serve to restore in part the needed perspective here so effectively eradicated.

A. A. BENNETT