EXTERIOR BALLISTICS: COMPILED AND ARRANGED AS A TEXT BOOK FOR THE USE OF CADETS AT THE U. S. NAVAL ACADEMY

Published @ 2017 Trieste Publishing Pty Ltd

ISBN 9780649463138

Exterior Ballistics: Compiled and Arranged as a Text Book for the Use of cadets at the U. S. naval academy by R. R. Ingersoll

Edited by Trieste Publishing Pty Ltd.
Cover @ 2017

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R. R. INGERSOLL

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COMPILED AND ARRANGED AS A TEXT BOOK

FOR THE USE OF CADETS AT THE U. S. NAVAL ACADEMY,

BY

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THIRD EDITION.

REVISED AND PARTIALLY REWRITTEN.

1893.

PRESS OF
DEUTSCH LITHO'G & PRINTING CO.,
BALTIMORE.

PREFACE.

This volume aims to present, in a simple form, for the purpose of the instruction of Naval Cadets, methods for the solution of the various problems in Ballistics which are likely to be met with in Naval Gunnery Practice.

For a more elaborate discussion of the motion of projectiles in a resisting medium, as well as for different methods for the computing of trajectories, the reader is referred to such works as those of Mayevski, Bashforth, Siacci, and the recent complete and valuable work of Captain James Ingalls, U. S. Artillery, whose works have been consulted in the preparation of the following pages.

Only one method for the complete solution of trajectories in air is here presented, on account of the limited time available for instruction at this institution in this branch, and also for the reason that the method selected will be found sufficiently accurate in practice for work with naval guns, while the labor of computation involved is very much less than is necessary for the same accuracy with many other methods.

The method adopted is that due to Major Siacci, of the Italian Artillery, and the foundation for the analytical work has been taken from a translation of Siacci's publication by Professor W. W. Johnson, U. S. Naval Academy.

The Ballistic Tables, computed by Lieut. Commander Ingersoll, are founded on Mayevski's discussion of Krupp's experiments at Meppen in 1881. The laws for the resistance of the air as deduced by Mayevski were published in the *Revue d'Artillerie*, April, 1883, and appear in this book converted to English units of weight and length. These equations are also to be found in "Exterior Ballistics," Captain James Ingalls, First U. S. Art., page 29.

The projectiles used in Krupp's experiments were of modern construction, three calibres long, with ogival heads of two calibres radius, and fitted with a forced rotating band, giving smoothness of flight. These conditions corresponding very closely to modern practice, it is thought that a set of tables founded on such experience will give accurate results when the data for similar projectiles are used. These tables may be used, however, when other conditions obtain, by using proper ballistic coefficients, as will be explained in the work.

Numerous examples, taken mainly from Examination papers since 1887, have been added.

The notes prepared from time to time in the Department of Ordnance and Gunnery have been embodied when applicable.

NAVAL ACADEMY,
DEP'T OF ORDNANCE AND GUNNERY,
July, 1893.

CONTENTS.

CHAPTER I.

Definitions.—*Ballistics* is the science of the motion of projectiles, and *Exterior Ballistics* is that branch of the science which is concerned with their motion when outside the gun.

As certain terms will be continually used in the discussion of this subject, their definitions are here given.

The *line of sight* is a straight line passing through the two sight points; in the act of firing, it also includes the target.

The *line of departure* is the line in which the projectile is moving when it leaves the gun; it is, therefore, the tangent at the muzzle of the gun to the curve described by the projectile.

The *axis of the bore* is its geometrical axis, and is the line along which the centre of mass of the projectile should move while in the bore.

The *axis of the trunnions* is their common geometrical axis, and in recent guns it intersects the axis of the bore at right angles.

The *angle of elevation* is the angle included between the line of sight and the axis of the bore.

The *angle of jump* is the vertical angle which the axis of the bore describes in the act of firing, and is due to want of perfect rigidity of gun and carriage.

The *angle of sight* is the angle included between a line passing through the gun and target and the horizontal plane.

The *angle of departure* is the algebraic sum of the angles of elevation, jump and sight, or is the angle included between the line of departure and the horizontal plane.

The *angle of fall* is the angle which a tangent to the trajectory at the first point of impact makes with the horizontal plane.

The *trajectory* is the curve described by the projectile in passing from the muzzle of the piece to the first-point of impact. It is a curve of double curvature in the case of rifled guns, but is usually treated as a plane curve.

The *range* is the distance measured in a straight line from the muzzle of the piece to the intersection of the trajectory with the line of sight.