Lehrbuch der Ballistik. By C. Cranz. Berlin, Julius Springer, 1925. xiv+711 pp.

This is the fifth edition of the author's first volume on ballistics, and it is confined to exterior ballistics. It is dedicated with appropriate courtesy to the late General A. von Kersting, the founder and first director of the Military Academy (1903–1912) who, during the first two years of the World War, rendered valuable service to German military technique as President of the Artillery Proving Commission. Proper acknowledgements are made to Major Becker for his work on ballistic wind and ballistic density, and to Professor O. von Eberhard who was the first to prove by actual computations the possibility of a trajectory of more than 100 km. in range.

Whatever might have been in the mind of Dr. Cranz in selecting the title of the book, the importance of its contents may be best described to the American reader by giving it the title *A Compendium of Exterior Ballistics*. The reviewer knows of no other volume on this subject that contains so much information together with such a thorough and masterly treatment of the subject. There are 539 pages of text and 267 pages of bibliography, ballistic tables, and ballistic diagrams. The references to literature are carefully assified as having special bearing upon definite articles. The bibliography alone makes the book highly desirable for a library.

In the first part of the book the author discusses in detail the trajectory in vacuo with numerous illustrations of the path of a projectile fired from an elevation and from an inclined plane. These are interesting and, of course, elementary. If the reviewer is at liberty to give his real impressions of the contents of a book, possibly I may be pardoned for saying that one of these examples struck me with surprise. The problem is as follows: "Is it possible to throw a stone from the top of the Great Pyramid out over the base." After reading that its altitude is 137.2 m. and that the side of its square base is 227.5 m. one remains somewhat at a loss to know what the problem really is until he meets the statement that the velocity of throwing from the hand is assumed to be 24m/s which, he explains parenthetically, is the mean of thirty tests made upon as many different persons. He does not state how these tests were conducted, nor does he describe the physical characteristics of the persons who did the throwing. He shows that it is possible to clear the pyramid with an initial velocity of about 20m/s provided that the stone is thrown at the proper angle and he concludes that it is possible to throw a stone clear of the pyramid with " a certain amount of skill." Merely to throw a stone 20 m/s requires very little skill. Certainly the thirty persons would be poor candidates for a baseball team if the average velocity with which they throw a stone is about 65 f/s. The baseball player, I should think, throws with a velocity of 150 f/s to 165 f/s. Skill in this case consists in throwing at 20 m/s from the very restricted area at the top of the pyramid.

He follows the usual course of deriving the differential equations of the trajectory and then presenting the different methods of integrating these equations and of constructing the trajectory graphically. A number of graphical processes are described beginning with that of Poncelet in 1848

and coming down to those developed during the World War and later. Two of these, one by Vahlen in 1918 and another by Brauer in 1918, call forth the comment by Dr. Cranz that it would be a worthwhile problem for the investigator in ballistics to substantiate the sufficiency and utility of both of these graphical processes. The Vahlen method depends upon vectorial addition; that of Brauer is based upon the hodograph.

The author's presentation of satellite, parabolic, and hyperbolic velocities is of more than usual interest and the figures that accompany this discussion are especially attractive. The effect of yaw is considered in detail both from the theoretical and practical standpoints. This is followed by the fundamentals in projectile design for all types of projectiles.

The subjects of vertical, near-vertical, and long-range firing are treated under separate heads. The first two of these, of course, apply to anti-aircraft fire. The third is of very great interest to all those who are interested in modern ballistics. This is the portion of the book for which Dr. Cranz gives credit to Professor Eberhard. Comments are made upon phenomena observed abroad in 1914 which have been observed in this country since that time. A projectile was fired under initial conditions which, according to Siaccian methods of computing the trajectory, would have given a range of 38 Km.; the observed range was 49 Km. The angle of elevation which gave the greatest range was in the neighborhood of 55°. In this country unusually long ranges, viewed from the standpoint of Siaccian ballistics, have been obtained by firing at high angles of elevation, the angle of elevation giving the greatest range being above 45°, and comparatively little difference in range for angles between 45° and 55° elevation. This is explained by the fact that the projectile encounters less resistance as it rises through lighter and lighter strata than if it had passed through only comparatively denser air as in lower-angle fire.

Probably a better illustration of the effect of the rotation of the earth upon a projectile might have been given than the one selected by the author. Certainly it is not usual to fire with a velocity of 5000 f/s (1600 m/s). Until more firing has been done at such high velocity and the results observed, his illustration is more in the nature of the prediction of the pure mathematician than that of the conservative military engineer. If this particular example is given to register surprise, others with smaller initial velocities should have been given.

The arrangement of the material and the clearness of presentation are such that the book might be made the basis of a course of lectures on ballistics. Such a course could be made very elementary and involve merely an intelligent use of the tables and formulas, but by delving into the more theoretical portions of the book, especially the parts relating to the rotating projectile, it may be made exceedingly difficult. The volume is not only a *compendium* of facts and methods relating to exterior ballistics, written by one whose pen has enriched the literature on the general subject of ballistics for more than thirty years and filled with data that could be assembled and classified only by a lifelong interest in the subject, but it is also the product of a high type of thorough and mature scholarship.

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