somewhat weak. The author writes rather as one defending the subject than as an historian of its progress, and too much emphasis is given to minor work. In the concluding chapter, on the advance of physics in Canada, A. N. Shaw gives a good general survey, outlining the present work in physics and the date of establishing laboratories, etc., at each of the Canadian universities. He points out the influence of the Cavendish Laboratory at which so many of the Canadian physicists have been trained. The history of physics in Canada is, of course, bound up with that of the late Lord Rutherford who in his ten years at McGill gave such a profound impulse to physics in the Dominion. The writer says: "Undoubtedly Lord Rutherford may claim sole responsibility for the greatest outburst of original research in Canada and the subsequent influence of his personality and works is beyond assessment."

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UNIVERSAL ALGEBRA

The Calculus of Extension

By Prof. Henry George Forder, including Examples by Robert William Genese. Pp. xvi+490. (Cambridge: At the University Press, 1941.) 30*s*. net.

About a hundred years ago, when Boole and Hamilton were extending algebra by symbolizing logical and physical entities, a similar but independent investigation was begun in Germany by Grassmann. Unlike the quaternions of Hamilton, which aroused considerable interest and became very well known, the calculus of extensive magnitudes of Grassmann attracted very little attention until the close of the nineteenth century. The appearance of Whitehead's "Universal Algebra" first made this theory well known to English readers, and the book still remains a classic, by providing an interesting and readable approach to the philosophy both of Boolean and Grassmannian algebra. The aim of the work now under review is to give a more detailed account of Grassmann's methods, and particularly to exhibit their power in all forms of geometry, metrical, kinematical and projective. The book is the outcome of many years experience and appreciation of the methods: it was begun twelve years ago as a result of perusing some mathematical notes on Grassmann left by the late Prof. Genese, and its publication has tarried through no fault of the author. The book, which goes far beyond the scope of the original notes, is full of information, and shows very clearly the power of the method and its surprisingly wide range of applications.

The calculus of extension is a form of non-commutative algebra which includes and absorbs ordinary vector theory. It can be developed in the abstract, and then applied, by means of its wealth of identities, to concrete problems in the theory of determinants, in nearly all forms of geometry, and in physics. In this respect it resembles analytical geometry, where the same algebraic form may represent at one time the locus of a point, and at another time the envelope of a line, according to the interpretation of the variables. This capacity for varied geometrical usage is, however, considerably greater in Grassmann's algebra than in co-ordinate geometry. It differs from the latter in discarding as unnecessary a co-ordinate frame of reference; and in this respect it returns to the earliest traditions of geometry.

The chapters run as follows: (i) Plane geometry, preceded by a page of bare axiomatic statements on extensive magnitudes, immediately interpreted as points and vectors. This leads to the use of similarity operators which provide neat proofs of remarkable theorems such as the Cayley Clifford problem of three-bar motion; (ii) Geometry of three dimensions, including spherical trigonometry; (iii) More axiomatic statements leading to projective geometry, where the richness of the method begins to be manifest; (iv) The theory of screws and the linear complex; (v) Differentiation and motion; (vi) Projective transformations. In Chapters vii–xv we have the general theory for any number of dimensions, including a discussion on matrices, and applications to quadrics in general, to circles, spheres and spherical 'spreads'. The final chapter, which bears on canonical forms, deals with the theory of algebraic products, recently developed by Müller, one of the chief exponents of Grassmann on the Continent.

The book is written most carefully and consistently; and it is evident that the author appreciates the value of a simple notation as an aid to thought. But it is doubtful whether the unfamiliar capital Gothic type for matrices is a happy choice in a work which seeks to persuade the reader to adopt a new outlook and new methods. The author endorses the motto adopted from Leibniz by Grassmann: *etsi omnis methodus licita est, tamen non omnis expedit*. It is surprising that a method of algebraic geometry can be pursued through so long a book without the mention of invariants and with the briefest allusion to the theory of groups. Nevertheless algebraists and geometers will find the book stimulating.

H. W. Turnbull.