CAJORI'S EDITION OF NEWTON'S PRINCIPIA

Sir Isaac Newton's Mathematical Principles of Natural Philosophy. Translated into English by Andrew Motte in 1729. *The translations revised, and supplied with an historical and explanatory appendix.* By Florian Cajori. University of California Press, 1934. xxxvi+680 pp.

The *magnum opus* of Newton, the *Principia,* is too well known to the scientific world to justify any elaborate description in a review of this nature. Suffice it to recall the fact that the first edition appeared in 1687 and that the errors and imperfections were numerous. Out of 494 pages W. W. Rouse Ball found that 397 were modified or corrected in the second edition—the one due to Cotes, of whom Newton remarked "If Cotes had lived, we had known something." After the second edition appeared Newton sent to Cotes a list of twenty errata, to which the latter added an equal number and remarked, "I made some Hundreds, with which I never acquainted You." Newton's only comment seems to have been, "Its impossible to print a book without some faults." All this goes to show that even the gods can err, and that a new edition of a classic of 1687 was justified nearly two and a half centuries later. It may also be remarked that Bentley, Master of Trinity, suggested that Cotes should include in the second edition "An alphabetical Index." Had Professor Cajori lived to see his own edition through the press, he might have recalled Bentley's good advice, especially as concerns the appendix. He died, however, before his manuscript was sent to the printer and, as the editor of the present revision, Professor R. T. Crawford, tells us, he left only the manuscript of the notes which form the appendix, even a preface being lacking.

This edition is a revision of Motte's translation from the third (Latin) edition (1726), use being made of Thorp's later translation (ed. 2, 1802). The only changes made in the text are such as relate to the symbolism and the phraseology, these being limited to such as are necessary to express the original ideas in modern form.

The work consists of the English text (626 pp.) and Professor Cajori's appendix (54 pp.). In the front matter are included Halley's "Ode Dedicated to Newton," translated into English by Professor Leon J. Richardson, and the prefaces to the first three editions, the one to the second edition, by Cotes (pp. xx–xxxiii), being of major importance. It is concerning the appendix, which contains the new material, however, that the reader will wish for information. A few of the most important items will therefore be mentioned, the space allowed for this purpose being limited.

In this appendix Professor Cajori discusses (p. 629 seq.) at length and with thoroughness the preface which Cotes wrote for the second edition, and in particular the theory of vortices which Descartes had published in 1644, more than twenty years before the *Principia* appeared. This theory had soon thereafter been made known in England by such scholars as Henry More (Cambridge) and Joseph Glanvill (Oxford) and by the publication (London, 1682) of Bonet's Latin translation of Rohault's French textbook on physics. Professor Cajori calls attention to the popular nature of this theory as compared with

Newton's laws of inverse squares in gravitational attraction. In spite of the difficulty experienced by the average student in reading the original text, however, the work had the support of such leaders as Halley, Whiston, Cotes, Taylor, Saunderson, Robert Smith, and both David and James Gregory. Nevertheless, even Whiston asserted that the Cartesian theory should first be taught "to the youth of the university" because it was easier, and Rohault's textbook continued in use, even in Newton's scientific home, until forty-three years after the *Principia* first appeared, and three years after its celebrated author found his last resting place in Westminster Abbey.

Professor Cajori gives a brief but clear summary (pp. 632–635) of the opinions of Newton's contemporaries and immediate successors concerning his real position respecting gravity. As a matter of fact, Newton himself confessed in a letter to Bentley, in January 1693 (N.S.), that he did not pretend to know its cause and, as is well known, he was opposed to hypotheses. All this is familiar to students of the Newtonian philosophy, but the facts are here well documented and an interesting comparison with the views of Einstein is made. The nature of gravitation is also discussed (p. 636) with respect to action at a distance—a theory due rather to Cotes in his preface to the second edition—and the relation of this to Maxwell's electromagnetic theory of light.

Although it is impossible in the space allowed to discuss at any length the most important topics of the appendix, the following items may at least be briefly mentioned as being of major importance, the numbers being those of the respective paragraphs:

11. Definition I, "The quantity of matter is the measure of the same, arising from its density and bulk conjointly," with reference to modern sources.

13. Absolute time, absolute space, place, and absolute motion, naturally leading to a statement as to the recent work of Ernest Mach, Michelson, Morley, Fitzgerald, Lodge, Lorentz, de Sitter, and Einstein.

14. Laws of motion, with reference to Kaufmann, Weyl, Eddington, and Einstein.

22. Kepler's problem, "To find the place of a body moving in a given ellipse at any assigned time," together with the scholium, essentially the solution of $x-e \sin x=z$, where e and z are known. A brief history of the problem is given.

23. "To find the motion of the apsides in orbits approaching very near to circles," with references to the study of S. B. Gaythorpe (1925), to Newton's work on the moon problem, and to the unfortunate controversy with Flamsteed. A valuable bibliography is included.

30. Fixed infinitesimals (Book II, Lemma II). Fluxions in the *Principia*, the relations between Newton and Leibniz. A summary of the history of the Newtonian calculus and a brief discussion of the obscurity of Newton. The treatment is much abridged, doubtless because of the amount of literature available.

35. On the resistance in a rare medium of a globe and a cylinder (Book II, proposition 34), with Newton's remark, "This proposition I conceive may be of use in the building of ships." This discussion is one of Professor Cajori's chief contributions. In it he considers the nature of surfaces of least resistance. His historical notes include the results set forth by Bolza.

38–49. In these notes Professor Cajori has entered one of the fields of his greatest interest—the history of physical problems. Those here discussed concern the velocity of sound, a field in which Newton did not meet with much success; the Huygenian telescope, the great length of the instrument being rendered unnecessary by Dolland's invention of the achromatic lens; the earth-moon test of the law of gravitation; the figure of the earth, and the problem of three bodies.

Newton's idea of God, his attitude toward hypotheses (*Hypotheses non fingo*), and his views concerning causality are considered in the closing pages (668–680). These naturally lead to a study of the workings of Newton's mind in general rather than to the mathematics of the *Principia*, but the discussion is none the less interesting, psychologically and historically.

Looking at the book from the mechanical point of view of the bibliophile, it is one of the finest pieces of printing and binding to be found among the mathematical books that have come from any press in this country. Congratulations are due to the University of California Press for such an excellent product. The lack of an index is its chief defect.

Thanks and congratulations are also due to the editor, Professor Crawford, for the painstaking care with which he has performed a very difficult task, and for his contribution to such a monumental work.

As to the work of Professor Cajori, he has here and more especially in his treatise on the history of mathematical symbols built for himself a noble and enduring monument, showing himself the leader among the historians of mathematics in this country and a conscientious and thorough scholar.

DAVID EUGENE SMITH

TARDI ON GEODESY

Traité de Géodésie. By P. Tardi. Paris, Gauthier-Villars, 1934. xxx+732 pp. 150 frs.

In a recent issue (vol. 40, No. 9, p. 644) of this Bulletin the reviewer considered Hopfner's book on geodesy and called attention to its highly theoretical nature. Captain Tardi's book is of a much more practical character. A good deal of space is devoted to directions for the use of instruments in the field. In this respect it resembles standard American text books on geodesy. This reviewer, however, will deal chiefly with the mathematical and theoretical portions.

Chapter 3, *Rappel de quelques théories mathématiques*, goes into some rather elementary matters of logarithms, trigonometry, infinite series, approximate formulas, the theory of errors, and the method of least squares. Many of the formulas are given without proof. The reviewer does not like the treatment of the Gaussian law of frequency of error, but this is a subject about which notoriously tastes differ.

Chapter 8 deals with the geometrical properties of the ellipsoid of revolution and of lines on its surface and applies the results to the calculation of a geodetic triangulation. Proofs are mostly given, at least in outline, but Gauss's fundamental theorem regarding the substitution of a sphere of the same mean curvature as the surface itself for the surface in question is merely stated with-