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-

out a precise reference to Gauss's memoir, or to any other place where the proof may be found. The theorem applies, of course, only to infinitesimal line elements but in practice its application is extended to lines of small but finite length; the errors committed by extending the theorem to lines of finite length are stated without proof but the source of the little table of errors is given. Legendre's theorem for the calculation of a spherical triangle like a plane one is developed and pushed to a higher approximation than is given by the usual practice of subtracting one-third of the excess from each spherical angle. The formula for the transfer of geographic coordinates (given the latitude and longitude of a first point and the distance and azimuth of a second point from the first to find the latitude and longitude of the second point) is developed in a simple form and one that seems to be sufficiently accurate in practice, although the reviewer has not had a chance to test it. The solution of this problem has been put in many forms, each aiming at a combination of theoretical rigor with simplicity in numerical computation; almost every national geodetic organization has its own variation of the process. The form given by Captain Tardi and reached by simple mathematical means seems to be due to him. It appears to be convenient and surprisingly accurate, considering the small amount of algebraic manipulation needed to obtain it.

Chapter 9 deals with the plane representation (mapping) of the terrestrial ellipsoid. However, it is mapping in a very restricted sense. Rectangular cartesian coordinates are much more convenient than latitude and longitude, that is, for the average person, to whom meridians and parallels are very imaginary lines indeed. During the World War much use was made of maps on which a rectangular grid was superposed, points being specified by their rectangular coordinates in the grid. Similar systems for the special benefit of land surveyors have been used in Germany for more than a century. Each of the formerly separate German states has its own origin and axes. The errors in surveying arising from identifying the point on the map, conceived enlarged to approximately natural scale, with the corresponding point on the ground can be made small, if the area considered is small. The practice in surveying varies according to the length of line and the accuracy desired. Short lines may sometimes be treated as if they were exactly identical with the line between corresponding points on the enlarged map. Longer lines or lines for which some accuracy is needed require certain corrections. It is desirable to choose such a system of mapping as shall make these corrections as small and as easy to compute as possible. Captain Tardi gives a good account of the subject, an account that has already been found useful by the U.S. Coast and Geodetic Survey, which has devised a set of mapping or coordinate systems for the benefit of the surveyors of the various states. Two states have officially adopted the systems proposed for them and others will doubtless follow, for much work has been done using the various proposed systems more or less unofficially. This fact explains why this particular chapter is treated at disproportionate length in this review. In using the chapter some misprints have been detected but they will probably cause little difficulty.

Chapters 10 and 11 on the calculation of triangulation and its adjustments by least squares are about what would be found in a good American textbook.

Chapter 16 on gravity is not a particularly satisfactory one. There is a brief

account of the Newtonian potential and of the earth's field of force. Some of the simpler formulas are derived, but other formulas are stated without proof. Among these are numbers (396) and (398), which must surely be wrong, for the terms added together are not of the same physical dimensions throughout; also number (399), in which a sign is wrong.

Chapter 17 gives some technical details on gravity and sketches the theory of the Eötvös torsion balance.

Chapter 18 sketches methods for determining the figure of the earth by triangulation and astronomical methods and gives some of the results. Chapter 19 returns to gravity and shows how the flattening of the earth may be determined from gravity observations. No mention is made of Stokes's formula whereby the irregularities of the geoid may be determined by gravity observations. Doubtless, however, the author was justified in omitting it; the actual realization is not for the immediate future, in spite of the fact that gravity can now be determined at sea; moreover, the mathematics involved is rather beyond the scope of the work.

The author has already considered a geophysical question, namely isostasy, in connection with the figure of the earth, whether determined by triangulation or by gravimetric methods. Chapter 20 treats another geophysical question, the rigidity of the earth. The determinations of this rigidity by means of the long-period ocean tides, the tidal deflections of the vertical and the variation of latitude are outlined. Naturally a subject like this, which bristles with difficulties, cannot be treated exhaustively in a few pages. The reader, however, is at least introduced to the subject and made to realize that geodesy is a branch of geophysics. When the geodesist undertakes to interpret his data he inevitably becomes a geophysicist.

Perhaps this review, by discussing only the mathematical side, the side on which the book is probably the weakest, may have given a too unfavorable impression of the work. It is an excellent book on the whole, somewhat more comprehensive and more advanced than the average American textbook. A few more bibliographical references would improve it. It ought by means of successive revisions to have a long life, though probably in the nature of the case not as long as the book that it was written to supplant, namely, Francoeur's *Geodesy*, the first edition of which appeared in 1835. Successive revisions of Francoeur underwent comparatively slight changes; finally the stock of the latest revised edition became exhausted and question arose whether to revise Francoeur still further or to start afresh; the decision was to start afresh and Captain Tardi, who had had considerable practical experience and training in theory was selected for the work. Changes are coming so fast nowadays that, however excellent Tardi's book may be, it is hardly likely to attain the astonishing longevity of Francoeur's.

W. D. LAMBERT