

The discussion of the records of part ii. and part iii., together with the meteorological data of the expedition, is in course of preparation by Professor Tait and Mr. Buchan.

PUBLICATIONS OF THE NAUTICAL
ALMANAC OFFICE.

In the first part of this volume, Professor Newcomb presents a detailed development of the perturbative function which is applicable to all cases, except extreme ones, in which a general development of planetary inequalities in terms of the time is sought, and by which any required derivatives of the function may be found with great facility. In order to afford some idea of its range of application, he compares this development with others having the same general object; viz., those of Laplace, De Pontécoulant, Peirce, Leverrier, Hansen, and Cauchy. The method of this development has previously been indicated by Professor Newcomb, in the *American journal of mathematics*, vol. iii. The second part of this volume of the 'Astronomical papers' (pp. 201-344) is a determination of those inequalities of the moon's motion which are produced by the figure of the earth, and is by Dr. G. W. Hill, assistant in the office of the *Nautical almanac*.

In Delaunay's 'Théorie du mouvement de la lune,' the perturbations of the moon by the sun were fully treated; but subordinate portions of the theory were in some cases unfinished, and in others untouched. Having waited more than ten years for the promised filling of these gaps by French astronomers, Mr. Hill has in this paper taken up, in his masterful way, the discussion of the perturbations which the moon undergoes on account of the figure of the earth, the appreciable character of which was first brought to light by the analysis of Laplace. In his 'Darlegung der theoretische berechnung,' etc., Hansen has dealt with these inequalities in a very thorough way; but Mr. Hill has investigated these perturbations to the same degree of algebraical approximation that Delaunay adopted in determining the solar perturbations, viz., to terms of the seventh order inclusive; and his memoir is thus most appropriately entitled 'A supplement to Delaunay's theory of the moon's motion.'

The third part of the same volume (pp. 345-371), by Professor Newcomb, treats of the

motion of Hyperion. In several papers published during the past five years, Professor Asaph Hall has shown a remarkable retrograde motion in the peri-Saturnium of its orbit, the period of its revolution being about eighteen years. At first sight, this result appears inconsistent with the law of gravitation; for it is easily shown that in the case of a body moving in an eccentric orbit, and disturbed by another moving in a nearly circular one, the secular motion of the peri-centre will always be direct. As Titan is much the brightest, and much the nearest to Hyperion, of all the satellites of Saturn, Professor Newcomb investigates the results of its attraction upon this satellite, and shows that the ordinary theory of secular variations is entirely inapplicable to the mutual action of these satellites, and that we have here an entirely new case in celestial mechanics. The ordinary theory of secular variations presupposes that the mean motions of any two bodies to which it is applied are incommensurable; so that to any given mean longitude of the one, will correspond, in the course of time, every mean longitude of the other. The conjunctions of the two bodies will thus be scattered through every part of the orbit. But four times the mean motion of Hyperion is nearly equal to three times that of Titan; so that, if the two satellites are in conjunction at a given time, when Hyperion has completed three revolutions, Titan will have completed four, and another conjunction will occur at very nearly the same point. In its outer form, this relation between the two satellites is somewhat analogous to that among the satellites of Jupiter; but it is quite different in its cause. Professor Newcomb develops the modified formulae applicable to this case; and among other results of interest is the determination of the mass of Titan equal to $\frac{1}{12500}$ part that of Saturn.

FORCHHEIMER'S TUNNEL-BUILDING
IN ENGLAND.

DR. FORCHHEIMER visited England in the spring of 1883, by ministerial authority, to inspect and report upon the class of engineering work represented by the title below, confining himself, for the most part, to tunnels in progress or recently completed. Several most instructive examples are to be seen there, and

Astronomical papers prepared for the use of the American ephemeris. Vol. iii. parts i.-iii. Washington, Government, 1884. 371 p. 8°.

Englische tunnelbauten bei untergrundbahnen, sowie unter flüssen und meeresarmen: ein reisereport. Von Dr. PHILIPP FORCHHEIMER, ingenieur, privatdocent an der königl. technischen hochschule zu Aachen. Aachen, Mayer, 1884. 8 + 69 p., 14 pl. 8°.