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.

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

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

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

engineers of other countries can learn much from their study.

He first describes and illustrates the method of constructing the portion of the London underground railway between Aldgate station and the Mansion house, by the way of the Tower. The difficulties encountered from gas and water pipes, sewers, and foundations of buildings, and the necessity of providing for the continuance of street-traffic, called for ingenious contrivances, by means of which the construction was successfully carried forward. Beton or concrete was used for the invert, beton or brick for the side-walls, and brick arches covered the top. All varied in thickness to suit the circumstances of the case, and the superincumbent load.

Next follows an account of the building of a tunnel in London for the Midland railway, with illustrations of the timbering employed in the work, and the tunnel cross-section found best adapted to resist the pressure of the London clay. A brief description of a contemplated subway under the Thames at Woolwich is then given.

The tunnel under the Mersey, between Birkenhead and Liverpool, a little less than a mile long, communication between the ends of which was opened early in 1884; and the Severn tunnel, not far from Bristol, to be four miles and a half in length, and now well advanced, — occupy in description about one-half of this report. The drainage-tunnel below the main tunnel under the Mersey; the arrangements for pumping and ventilation; the introduction of Col. Beaumont's machine, which had previously bored five thousand linear yards through chalk in the proposed tunnel under the English Channel, and here bores a hole seven feet in diameter through the sandstone rock, — are well described. The Severn tunnel is prosecuted with drills driven by compressed air. Progress has been hindered from time to time by the influx of water, even to the extent of completely flooding the works. The pumps required are consequently very powerful, having a capacity of eighty-two thousand six hundred cubic metres in twenty-four hours.

With the exception of two pages devoted to an intercepting or trunk sewer at Brighton, the closing pages are devoted to an account of the examinations and investigations already made in regard to a tunnel under the English Channel, between Dover and Calais, the present state of the project, and the possibilities of the scheme.

The book is handsomely printed, and the illustrations are very clear and explicit.

NOTES AND NEWS.

IN a lecture at Johns Hopkins on the place of the science of hygiene in a liberal education, Dr. Billings states the objections to the establishment of such a course, as follows: first, that there is no existing demand on the part of students for it; second, that the subject is not yet on a scientific basis; third, that the present courses of instruction given in the chemical, physical, and biological departments of the university, include all that a well-educated man need know of this subject, unless he proposes to make it a specialty; fourth, that the students have no time for any studies additional to the course already supplied. To the first objection Dr. Billings replied, that the same might be said as to other branches of the curriculum, — that the majority of students do not know what they ought to study, — and that the question is, whether the time has not come to create the demand, and for the university to lead the way in the matter. The second objection is only partly true. The general rule holds good in man, as it does in the laboratory, that like causes, under like circumstances, will produce like effects. When it has been shown in a number of well-marked cases that polluted water has been the means of spreading typhoid-fever, that overcrowding and foul air precede epidemic typhus, that scarlet-fever or diphtheria has been conveyed to a village by infected clothing from a distance, we have enough information to enable us to advise in similar cases, although we also know that men have drunk sewage with impunity, and that unprotected children have slept in the same bed with a scarlet-fever case and have not taken the disease.

— The foundations under the stone piers supporting the iron bridge, twenty-five feet above low-water level, by which the Wabash, St. Louis, and Pacific railway crosses the Kankakee River, have lately been giving trouble. The bed-rock of shale is hard and soft in places in the short space of a few feet. The three piers were built when the water was high, and were placed on platforms of four thicknesses of pine timber twelve inches square. Before these platforms were located, some of the loose material was removed; but it would appear that the foundation was dug deepest in the centre, and the rapid current of high water washed under and disturbed the piers. In order to fill the space, give a firm bearing over all the bottom, make the piers thoroughly durable, and at the same time not interrupt or interfere with the traffic over the bridge, the application of wooden wedges was suggested and carried out by P. E. Falcon of Chicago. By a strong jet of water and other appliances, the sediment and loose material were cleared away by divers from under two timbers at a time, and the bed-rock was cut away to a level. Oak timbers were fitted to the cavity; and a double row of broad oak wedges, to insure a complete bearing from the middle of the pier to the outside edge, was driven between the oak timbers and the pine platform by means of a steel bar weighing eight hundred pounds, suspended from the bridge by wires, and adjusted to