proposition has been made in England, and has been carried out by the Ethnographical Museum in Berlin. Although the separation of the exhibit collections and the storage collections involves considerable administrative difficulties, and is open to scientific objections, it is not impossible that we shall necessarily be led to the adoption of this principle of administration. While, however, the collections are concentrated in one large building, we must accept the principle that the collections must receive proper care, and must be available for scientific study. In our museum buildings with which we have to get along at the present time, this end might very well be attained by placing either in one wing or on one floor the exhibits intended for the general public, and also those intended for students in high schools, special training schools, colleges, and even for many students of universities. In collections of this kind the more advanced collections intended for students would give what I called before the indifferent background which is so necessary for the general public. A large number of halls, however, will have to be installed in a more condensed manner, perhaps by adding galleries to halls of unnecessary height, in which material could be made accessible to students. There is no reason why the public should not be admitted to halls of this kind, although presumably very few of the visitors would carry away any other impression than that of the magnitude of the field of work covered by the museum. A thorough reorganization of museum administration will not be possible until the plan of operation of the museum is decided upon before the museum building is erected, and until the small systematic educational museum, which serves as an adjunct to elementary instruction, is separated entirely from the large museum. Like the university, the large museum must stand first and last, in its relation to the public as well as in its relation to the scientist, for the highest ideals of science.

FRANZ BOAS

SCIENTIFIC BOOKS

THE COLLECTED WORKS OF GEORGE WILLIAM HILL

THE Carnegie Institution of Washington has already undertaken many forms of scientific activity during the short period of its existence. These may be divided into two classes. First, the cases where it assists science indirectly by a grant to an individual for the prosecution of some piece of work which might or might not be done without this aid; and second, the cases where some particular branch of knowledge is to be advanced or assisted by expenditure on lines which will not benefit any individual in particular, either in money or in reputation. There is considerable doubt whether an ultimate gain is to accrue to the scientific world from the former method: the danger of pauperizing research is a matter which can not be regarded lightly, for the most notable contributions have more frequently been made by those who have done their work in spite of difficulties and who, under an easier régime, would not have felt the need for exertion. Little criticism can be made on the second class of cases, where organization and a large equipment is frequently required. The routine work involved in making or collecting or publishing huge masses of data is often neither possible for an individual nor stimulating to any one who is obliged to undertake it for some definite object which he may have in view.

To the second class belongs some of the work that may be done by a publishing house whose sole concern is not the maximum financial gain to be extracted from its operations. Of this there already exist excellent English examples in the Pitt Press at Cambridge and the Clarendon Press at Oxford. It is true that these businesses are run on a commercial basis in so far as they publish books which appeal to a large circle, but they also issue works on which a considerable financial loss is expected, so that the net annual profit is not large. The trustees of the Carnegie Institution early recognized the fact that similar opportunities were needed in the United States for publications which the scientific societies are too poor to undertake, and which, for a business firm, would simply mean a gift to education. The subject of this article is one of the earliest projects of the institution; its successful completion gives reason to hope that it may be the forerunner of others on the same lines.

The memoirs of Dr. G. W. Hill occupy over seventeen hundred pages arranged in four quarto volumes. Of these just one third (Vol. III.) are taken up by his well-known theory of Jupiter and Saturn. In his preface to this work Dr. Hill says: "It was desired to abandon the use of the antiquated tables of Bouvard, and it appeared uncertain when Leverrier would publish his. The plan, therefore, was to form theories of Jupiter and Saturn which would be practically serviceable for a space of three hundred years on each side of a central epoch taken near the center of gravity of all the times of observation; theories whose errors in this interval would simply result, not from neglected terms in the developments, but from the unavoidable imperfections in the values of the arbitrary constants and masses adopted from the indications of observation." How well he succeeded is now beginning to be seen. The observations which were used in forming the tables ended with the year 1888. In memoir 76, a comparison between the results of theory and observation is given from 1889 to 1900 which shows that the mean error for each year in right ascension and declination scarcely exceeds one second of arc. And further, unlike the comparisons from the majority of astronomical tables, the errors show no tendency to increase steadily as time goes on.

But the subject which is more closely associated with Dr. Hill's name is the theory of the moon's motion. It is difficult to overestimate the services which he rendered by the publication in 1878 of the one memoir, 'Researches in the Lunar Theory.' Before this time there had been a growing feeling amongst mathematicians that the motions of the moon and planets, as subjects for investigation on theoretical lines, had been worked out and that there was little to attract a student unless he wished to take up the practical side by more accurate computations of existing developments. This false view of the situation was corrected in a single step, although it was reserved for Poincaré to show the full importance of the advance which had been made by his development of Hill's idea of the periodic solution. But the advance from the point of view of computation was not far behind, since this paper also laid a basis for the accurate calculation of the moon's motion without the excessive labor which the earlier theories would have demanded. The newly awakened interest in celestial mechanics is made sufficiently evident by the fact that over twenty treatises and text-books have appeared during the last thirty years and these quite apart from scores of original memoirs.

Connected with this paper was the memoir on the motion of the perigee of the moon, in which the idea of a determinant with an infinite number of elements to solve an infinite system of linear equations was introduced and used as a powerful instrument for accurate computation. In the introduction written by Poincaré and printed in the first of the four volumes the latter says: "Avait-on le droit d'égaler à zéro le déterminant de ces équations? M. Hill l'a osé et c'était là une grande hardiesse; on n'avait jamais jusque-là considéré des équations linéaires en nombre infini; on n'avait jamais étudié les déterminants d'ordre infini; on ne savait même pas les définir et on n'était pas certain qu'il fût possible de donner à cette notion un sens précis." * * * "Mais il ne suffit pas d'être hardi, il faut que la hardiesse soit justifiée par le succès. M. Hill évita heureusement tous les pièges dont il était environné, et qu'on ne dise pas qu'en opérant de la sorte il s'exposait aux erreurs les plus grossières; non, si la méthode n'avait pas été légitime, il en aurait été tout de suite averti, car il serait arrivé à un resultat numérique absolument différent de ce que donnent les observations." But is there not something more than the mere numerical agreement? Does not intuition, conscious or unconscious judgment, penetration into the heart of a matter—whatever we like to call it—play a large part in the selection of means to an end? It is not necessary—is it even advisable?—to stop and consider the theoretical possibilities of a new step if one feels certain it is to lead to the desired end, especially in the application of mathematics to physical problems. If astronomers had known that the series they were to use were nearly all divergent without at the same time knowing that they could still be used, would they have been inclined to undertake the enormous calculations which have resulted in our present tables for the positions of the moon and planets?

The centipede was happy till
 One day the toad in fun
Said, "Pray, which leg comes after which?"
This raised his thoughts to such a pitch,
He lay distracted in a ditch,
 Not knowing how to run.

At the same time, one does not in the least wish to depreciate the value of the labors of those, and above all of Poincaré himself, who have rendered such magnificent services to the cause of pure science by placing the methods of the applied mathematicians on a secure foundation.

In reading through the memoirs there are certain features of Dr. Hill's work which impress themselves on the mind. His power of dealing with long and complicated expressions with apparent ease is often the secret of his success. Unlike the methods in the two papers just mentioned which possess an excellent symmetry of mathematical form, expressions best adapted for computation are usually least symmetrical. And the reason for this is not difficult to understand. For the symmetry frequently implies some kind of relation between the symbols constituting the expression, which relation can often be used for abbreviating the work. In many cases one would shrink from attempting to reduce Dr. Hill's formulas to numbers, but he rarely fails to give one or more numerical examples to show how his methods can be applied. For instance, in memoir 79, which is an attempt to introduce the use of purely periodic terms to express the coordinates of the planets in terms of the time, instead of the usual method which involves secular terms, he estimates that some 2,800 special values of a certain expression will have to be computed. He immediately sets out the computation and the results for 175 of these to 13 places of decimals. And again, in the last paper on 'Dynamic Geodesy' in which he examines methods for computing the effects of the continents and seas in order to obtain a more accurate expression for the value of gravity at any place, there are five suppositions as to the distribution of the earth's mass; in each case the value of g and the deviation of the plumb line is found at several positions on the earth's surface.

The freshness and originality of Hill's work make it difficult to attach him to any particular school of mathematicians; if any such attempt is made, he belongs perhaps more closely to that of the mathematical astronomers of the latter part of the eighteenth century, and of their immediate successors. This is not unnatural, for it was to them that he owed his first inspiration. But his methods are essentially his own, even when he is expounding or using the work of his predecessors. We perhaps need more such men, lest the font of originality be choked up by the attempt to assimilate the mass of work which is being turned out every year in increasing quantities. That Dr. Hill has by no means ceased to contribute his share is shown by the last five papers contained in over a hundred pages which had not previously been published. The range of subjects is sufficiently varied. Two are continuations of memoir 79, to which reference has already been made; one is on the development of the disturbing function; one on the construction of maps, in which he sets forth a method for the better representation of large areas of the earth's surface or of the sky on paper; and the final one, also mentioned above, on geodesy.

It is to be regretted that the paper used for the reproduction is thick and unsized. In consequence of this the volumes are heavy and those who wish to make notes will find it necessary to use a sharp pencil rather than a pen if the writing is to be legible. In other respects, the printing is good and clear, and wide margins are supplied.

In closing this brief notice, I can not do better than again to refer to the introduction. In the last paragraph, M. Poincaré says: "Ainsi aucune des parties de la Mécanique Céleste ne lui a été étrangère, mais son œuvre propre, celle qui fera son nom immortel, c'est sa théorie de la Lune; c'est là qu'il a été non seulement un artiste habile, un chercheur curieux, mais un inventeur original et profond. Je ne veux pas dire que ces méthodes qu'il a créées, ne sont applicables qu'à la Lune; je suis bien persuadé du contraire, je crois que ceux qui s'occupent des petites planètes seront étonnés des facilités qu'ils rencontreront le jour où en ayant pénétré l'esprit ils les appliqueront à ce nouvel objet. Mais jusqu'ici c'est pour la Lune qu'elles ont fait leurs preuves; quand elles s'étendront à un domaine plus vaste, on ne devra pas oublier que c'est à M. Hill que nous devons un instrument si précieux."

E. W. B.

Pocket-book of Aeronautics. By HERMANN W. L. MOEDEBECK in collaboration with O. CHANUTE and others. Authorized English edition translated by W. MANSERGH VARLEY. London, Whittaker & Co. 1907. Small 8vo. Pp. 496.

Moedebeck's 'Taschenbuck für Flugtechniker und Luftschiffer,' which first appeared in 1895 as a little volume of 198 pages, besides the ruled pages for entering observations, was intended to be carried in the pocket of the experimenter or aeronaut, and although a useful compendium it was hardly known outside Germany. A new and greatly enlarged edition (which renders the name 'pocket-book' inappropriate) has just been issued, and through the generous help of Patrick Alexander, an English gentleman interested in aeronautics, who cooperated with Mr. Chanute, the eminent Chicago engineer, the revised treatise has been made accessible to English readers.

The following summary of its contents will show the scope of this useful and timely handbook. Chapter I. deals with the gases used in filling balloons, and the next chapter, by Professor Kremser, a Berlin meteorologist, treats of the physics of the atmosphere. The observations in the free air quoted were, however, obtained in Europe and no reference is made to the large amount of data collected with kites in the United States by our Weather Bureau and at the Blue Hill Observatory, nor to the more recent observations with balloons at great heights, which were instituted by this observatory. The same writer, in Chapter III., gives practical directions for making and reducing balloon observations, but the translator has confused some of the meteorological symbols. In the next chapter Major Moedebeck discusses the technique of ballooning with which Chapter VI. on ballooning might properly have been combined. Kites and parachutes are treated in Chapter V. by the Hamburg meteorologist, Professor Köppen, who was one of the first persons in Europe to experiment with kites for meteorological purposes after their usefulness had been shown at Blue Hill in 1894. It may be said that neither figure 51*b* nor 53 represents a typical Hargrave kite, H. H. Clayton having invented this form with four continuous corner-sticks. Alexander Graham Bell's tetrahedral kite is omitted from the types described, notwithstanding the fact that the fame of the inventor has attracted wide attention to it. No mention is made of the practise of using larger wire for the lower portions of the line which enables great heights to be attained by attaching successive kites. The bibliography should include the important memoir by S. P. Fergusson, describing the perfected equipment at Blue Hill, which was published in *Annals of Harvard College Observatory,* Vol. 43, Part 3. In Chapter VII. balloon photography is discussed by Professor Miethe, an eminent authority, as is, in the following chapter by Professor Kutta, the allied subject of photographic surveying. Next comes a detailed account, by Major Moedebeck, of the history and present status of military ballooning in the different countries of the world. The editor's technical knowledge of the subject gives authority to his estimate of the value of the future air-ship in warfare.

The remainder of the book is mainly devoted to dynamical aeronautics. Professor Müllenhoff analyzes briefly the principles of animal flight in Chapter X., and in the first part of the next one, Major Moedebeck gives the history of man's attempts at flight. In the same chapter a paper by the late Otto Lilienthal on artificial flight is followed by Mr. Chanute's account of the modern experiments where one looks in vain for any mention of the remarkable machines of the late Professor Langley. In Chapter XII. Major Moedebeck describes the air-ship or motor-balloon, in the list of whose performances, by some error, the drifting race of spherical balloons in 1906 for the Gordon-Bennett cup has been included, with the name of the winner strangely distorted. The next three chapters, on flying-machines, their motors and screws, are by the well-known Austrian expert, Major Hoernes. Chapter XVI., the last one, contains a convenient list of the aeronautical societies of the world and an appendix has a useful collection of tables and formulæ. The index is inadequate to so much material, but, in spite of this and some minor defects, the work can be highly recommended to the increasing number of persons interested in the investigation or navigation of the air, as the best existing treatise on this rapidly-developing subject.

A. LAWRENCE ROTCH

BLUE HILL METEOROLOGICAL OBSERVATORY

SOCIETIES AND ACADEMIES

THE AMERICAN CHEMICAL SOCIETY. NORTH-EASTERN SECTION

THE seventy-seventh regular meeting of the section was held at the State Mutual Restaurant, Worcester, Mass., on May 18, at seven o'clock P.M. The paper of the evening was upon 'Ceramics,' by Dr. Frederic Bonnet, Jr. The speaker first referred to the importance of the clay-making industry, it being the third in magnitude and only surpassed by those of coal and iron. The value of clay products in 1905 reached the immense sum of $145,697,-188. Of this, brick represent nearly one half. Clay consists of naturally occurring earthy materials having more or less plasticity when wet, and which, when heated to redness or higher, becomes hard and rocklike. Clays are of secondary origin, and are the product of the decomposition of feldspathic or serpentine rocks. Brongniart, and also Dr. Cushman, of the U. S. Department of Agriculture, testing laboratory for road materials, have made researches which indicate that the decomposition of the feldspar is a kind of electrolysis, in which the alkali constituent passes into solution, leaving the alumina and silica. The noted deposits of Cornwall, England, Zettlitz in Bohemia and certain deposits in Germany, however, appear to have resulted from the action of acid vapors on feldspar. Deposits formed by weathering are usually shallow and the original feldspar is found beneath. True kaolin is formed from feldspar and is essentially a basic hydrated aluminum silicate. If the clay has been transported by water and again deposited, it usually contains some impurities; if little iron is present and the clay is tough and plastic, it is called ball clay. The cause of plasticity is not fully understood and no entirely satisfactory theory has been advanced. One of the most recent, the colloid theory, fails to meet the case and does not explain the cohesiveness of a ball clay. The history of pottery is, to some extent, the history of man; from the crude pots of primitive races to the decorative ware and porcelain of advanced civilization. Clay is often used just as it is found for brick, tile and common pottery, but for all better ware it needs selection and preparation. In the finest ware and for some special purposes, it is subjected to very fine grinding and mixing, or long tempering and ageing. The effect of silica on the fusion point of clay is very important; pure kaolin fuses at temperatures about 1,800° C., or higher, but free silica lowers this, and hence should not be present in too great an amount in fire-clays. But metallic oxides are the most noticeable fluxes in clays; the fusion point decreases as the percentage of bases rises. But the bases exert this depressing effect on the fusion point in proportion to