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THE BUDAPEST CONFERENCE OF THE INTERNATIONAL GEODETIC ASSOCIATION.

THIS account of the recent meeting of the International Geodetic Association is necessarily unbalanced and incomplete. It must be brief. The formal minutes of the meeting were not available for use while preparing the report. It is not easy for one to appreciate fully all that occurs in a meeting in which the proceedings are carried on in three languages. Nevertheless, it is believed that a prompt report, calling attention to some of the more important features of the meeting will be of value, even if the report has defects.

The Fifteenth General Conference of the International Geodetic Association was held at Budapest, September 20–28, 1906. Such conferences of the association are, in general, held at intervals of three years.

There were present 61 delegates, representing 18 nations. Nearly every part of Europe was represented, as well as Japan, Mexico, the United States and Argentina. Argentina was represented in the association for the first time at this meeting.

The United States was represented by the undersigned.

The activities of the conference may conveniently be grouped in four classes and such grouping is favorable to a clear understanding of the purpose and effect of the conference. The activities were: (1) The presentation by the representatives of the different countries of reports of the progress in geodetic operations during the

past three years in those countries; (2) the presentation of special papers bearing upon improvements in instruments, methods of observation and methods of computation; (3) the transaction of the business of the association itself at the conference, in connection with the continuous operation of the central bureau maintained at Potsdam and in connection with the field work being done by the association as an organization; and (4) the social features of the meeting.

Through this and similar conferences a close and effective cooperation of many men of many nations, acting as an association, is secured in a certain few lines of research. Of these the greatest now being carried forward is an investigation of the variation of latitude.

Aside from this cooperation, all the activities of the conference served to make it a clearing house for ideas, a place where each may learn what ideas, old or new, are being acted upon in geodetic work in other countries than his own. In this process the social functions play an important part in bringing men together and helping them really to understand each other.

The association, as such, does not fix the methods of observation or computation in any country. It controls only the methods used in its own central bureau and in the field work paid for from the association funds. But, by virtue of the active interchange of ideas which takes place at the conferences, the association undoubtedly exerts a strong influence in making the methods used in various countries much more uniform and progressive than they otherwise would be.

The reports of progress within the past three years which were submitted show that the rates of progress in accumulating new results are very different in different countries, depending upon a great variety of conditions. Each country brought some contribution and the total represents a rapid increase in the mass of geodetic facts available for future use. It would be tiresome to summarize these reports here and the summaries would be of little value. Three items are, however, of special interest. Progress has been made within the last three years in the observations and computations connected with an arc in Spitzbergen and in connection with the remeasurement of the classical Peruvian arc, extended. Progress has also been made in South Africa on the measurement of an arc which is expected, ultimately, to extend from the Cape of Good Hope to the northern part of Russia, a total length of 104°.

Let us turn now to the special papers bearing upon improvements in instruments, methods of observation and methods of computation.

Th. Albrecht, of Germany, presented a report on a thorough investigation made at and near Potsdam, of the applicability of wireless telegraphy to the accurate determination of differences of longitude. The transmission time was found to be extremely small and sensibly independent of the particular receiver used and of the intensity of the sending.

Though not a delegate to the conference, Ch. Ed. Guillaume, of the International Bureau of Weights and Measures, by special invitation occupied the greater part of one session in presenting the results of the many tests of the Invar (nickel-steel) wires made at the International Bureau, describing the apparatus devised there for the rapid measurement of bases with Invar wires, and in giving a general statement in regard to the use of this apparatus in the measurement of a base extending the entire length of the recently completed Simplon tunnel. The extensive investigations of the International Bureau

show that the changes in length to which the Invar wires are subject are so small, and that the Invar wires have such physical properties, that they are suitable for the measurement of primary bases. The experience in the Simplon tunnel confirms this conclusion. The base apparatus there used is elaborate in comparison with that now in use in the United States for the measurement of primary bases with steel and Invar tapes. It also differs radically from the Coast and Geodetic Survey (U. S.) apparatus in having the entire measurement carried forward on movable tripods, just as measurements with base bars are made, instead of being carried forward on stakes driven in the ground, as are the tape measurements in the United States. The Simplon tunnel base was 20 kilometers long. The tunnel was placed entirely at the disposition of the measuring party for five consecutive days, no trains being run during that time. The measurement was made continuously in each direction through the tunnel, the party working in shifts of eight hours, day and night. The forward measurement was made in 59 hours. The remeasurement was made, after a day of rest, in 27 hours. The total number of persons employed on the measurement at any one time was 28. Seventy-seven different persons in all were involved in the measurement. This performance and its results leave no doubt that the necessary accuracy can be secured more quickly and conveniently with Invar wires than with any bar apparatus. Any one who will carefully compare this work, in all respects, with what has been accomplished with steel and nickel-steel tapes in the United States, on primary base work, will also be convinced that all the advantages claimed for wires may also be claimed for tapes, and that the use of tapes, rather than of wires, and of stakes, rather than of tripods, makes the measurement much more rapid, economical and convenient, and that the tapes are more reliable, as to length, than the wires.

Baron Eötvös, of the University of Budapest, occupied the greater part of one session in presenting a discussion of the results secured by him with certain torsion balances of special design. A similar presentation may be found in *Wiedemann's Annalen,* 1896, and another in the report of the Congrès International de Physique, Paris, 1900. He evidently aroused much interest. The conference visited his laboratory in a body to see the apparatus. He derives from the observations the first differentials of gravity with respect to distance measured along the three rectangular axes at the point of observation. From these observed quantities may be derived various other quantities, such as, for example, the radii of curvature of the geoid at the point of observation. The claims made as to the simplicity of the manipulation of the apparatus, the accuracy of the results, and the certainty with which the positions of the excesses and defects of mass within the earth may be determined by such observations, are astonishing. If the validity of these claims is established by future investigations, these torsion balances will become very important as being the most powerful means available for determining the distribution of density within the earth.

Dr. O. Hecker exhibited the very interesting apparatus which has been used by him, under the direction of the association, for determining the value of gravity at sea. He presented the results of recent observations made with this apparatus on the Pacific on two voyages between Sidney, Australia, and San Francisco, and between San Francisco and Yokohama. The atmospheric pressure is determined in terms of millimeters of mercury by a mercurial

barometer and simultaneously the pressure is also determined in absolute units by an accurate observation of the boiling point of water, using mercurial thermometers. From these simultaneous observations the intensity of gravity at the point of observation is computed. This method is entirely successful in determining gravity with the accuracy necessary for an effective study of the anomalies in gravity. This is the only successful method yet devised for determining gravity at sea with sufficient accuracy. Such observations are of extreme importance to geodesy, because they are the only geodetic measurements possible over three fourths of the globe. Hecker's observations show that, in general, over the deep Pacific gravity has nearly its normal value, as computed by Helmert's formula of 1901, fixing the relation between gravity and latitude. Parenthetically, it may be remarked that this indicates that the condition called isostasy exists. Four regions with large anomalies, with reference to Helmert's formula, were found. Near Oahu, one of the Sandwich Islands, gravity is considerably in excess at sea, just as it has already been observed to be on the island. There is a region of excessive gravity in shallow water near New Zealand. Over the submerged Tonga plateau, where the depth is 3,000 meters, gravity is largely in excess and in the adjacent Tonga deep (5,000–10,000 meters) there is a large defect of gravity.

H. Kimura, of Japan, reported on a harmonic analysis of the variation of latitude which has been made by him. The analysis develops the very interesting fact that in addition to its other motions, already approximately known, the pole has a reciprocating motion approximately along a straight line, with a period of about 0.75 year, a period which is not commensurable with any of the other known periods of the polar motion.

Lallemand, of France, for many years the authority on precise leveling, stated that a series of experimental comparisons had been made in France between the French instrument and method and the instrument and method used in the U. S. Coast and Geodetic Survey since 1900. The conclusion reached was that the degree of accuracy is sensibly the same in the two cases, because in each the instrumental errors have been made so small that the errors in the results are mainly due to meteorological conditions, that is to conditions between the object glass and the rod.

On the part of our own country there was presented a special report upon a recent determination of the figure of the earth, made by the Coast and Geodetic Survey and based entirely upon deflections of the vertical observed in the United States. This report showed that to secure the highest degree of accuracy in such determinations the theory of isostasy must be taken into account; that the United States is not maintained in its position above sea level by the rigidity of the earth but is, in the main, buoyed up, floated, because it is composed of material of deficient density; and that the defect of density is limited to the depth of 71 miles, if it is uniformly distributed with respect to depth. This report, if it is convincing, must ultimately produce radical changes in the methods of computation used by geodesists. It also has a direct bearing upon several of the greater problems of geology and of geo-physics.

The activity of the association itself, as distinguished from the activities represented by reports of progress and special papers, is indicated by the fact that the average rate of expenditure for the past three years has been $19,000 per annum. This covers administration, printing and postage, the maintenance of the central

bureau and such field work as is paid for by the association.

The principal work of the central bureau, under the direction of Dr. F. R. Helmert, may be summarized as follows:

Relative gravity determinations in various countries have been furthered by special examinations in detail of apparatus to be used for this purpose and by instructing the observers.

Professor Borrass has been occupied in studying the existing relative gravity determinations with a view to their proper combination in a gravity net extending over the globe.

A systematic study of deviations of the vertical in Europe has been continued by Professor Börsch, and progress has been made in the publication of the results.

A systematic study by Dr. Helmert of the curvature of the geoid along certain meridians and parallels, in countries where there is extended triangulation, has been nearly completed.

The determination by Dr. Kühnen and Dr. Furtwängler of the absolute value of gravity at Potsdam which has been in progress for several years has been completed and the final results are now being printed. In these determinations, five different pendulums have been used at Potsdam and a very extensive series of observations have been made with great care. It was found that the general experience of the past was repeated and that systematic differences, much too large to be accounted for as errors of observation, were found between the results from different pendulums. In trying to account for the large residual furnished by one of the five pendulums, which was of peculiar form, the suspicion arose that possibly the stem of this pendulum was subject to flexure, as the pendulum took various positions during each swing. Accordingly, a mathematical theory of such a possible flexure was developed fully for the first time. The effect of the flexure upon the value of gravity given by each of the five pendulums was then computed, using this mathematical theory which expresses the effect in terms of the modulus of elasticity of the material composing the stem, the dimensions of the stem, and the masses of different portions of the pendulum. The corrections brought the results into closer agreement. The same theory was, with similar success, applied to six other series of pendulum observations made at various times and at places connected with Potsdam by accurate relative determinations of gravity. In these series, pendulums of various designs have been used. The adopted value of gravity at Potsdam is a simple mean of the seven values, one of these being the value observed at Potsdam. The adopted mean differs by one part in 25,000 from the Potsdam determination. Helmert states that he believes the possible error of the adopted mean to be less than one part in 100,000. The total range of the seven values is one part in 33,000.

Two of the seven values depend upon observations made with the Bessel ball and wire pendulums. For these the complete theory developed by Bessel for taking account of the flexure of the wire was used without modification.

The gravity determinations at sea by Dr. Hecker, already referred to, were made under the direction of the central bureau and paid for by the association.

The principal field work, supported by the association, is the determination of the latitude variation. For the latitude observations and the necessary computations of them, made at the central bureau, the expenditure has been, on an average, $14,000 per year, during the past three years, more than two thirds of the total expenditure of the association. From 1899 to date, observations have been made continuously at

six stations, all in latitude 39° 08′ north, and surrounding the pole. In 1906, two stations in the southern hemisphere were established, in Argentina and in Australia. The observations at all of these eight stations will be continued at least until 1909. The accuracy with which the motion of the pole is followed by these observations may be inferred from the fact that Kimura writes with confidence that the movement having a period of 0.75 year exists, though its total amplitude is apparently 0.06″ (6 feet) or less.

By a formal resolution, transmitted to it in advance of this meeting, the association was asked by the International Association of Academies in what way it could sustain or promote international cooperation in the following two matters: (*A*) Leveling of precision in chains of mountains subject to earthquake, with a view of determining whether such chains are subject to changes in elevation; (*B*) measurements of the value of gravity for the purpose of throwing light upon the internal distribution of terrestrial masses and upon the rigidity or isostasy of the crust of the earth. This resolution is the result of action taken at the International Geological Congress, held in Vienna in 1903.

A special report on that part of the resolution which refers to leveling was, by request, prepared in advance by Lallemand of France. He set forth the rather discouraging past experience in this line and indicated the essential difficulties of the problem. He reported that determinations of the stability of the ground by means of precise leveling, repeated at long intervals, should be made in all regions, not simply in chains of mountains subject to earthquakes; that ordinarily a general change of elevation of less than one decimeter can not be detected with certainty; and that each country should repeat the leveling, over at least the principal lines of its precise level net, two or three times in each century.

Darwin, of England, prepared in advance, by request, a report on that portion of the resolution which refers to gravity determinations. He suggested a resolution in reply to the effect that the association welcomes the resolution transmitted to it as showing that geodetic observations throw light on the science of geology, and that the association further desires to impress on geodesists who may be planning future gravity observations that it is desirable that the sites for observation should be chosen with reference to such use of the observations.

The recommendations made by Messrs. Lallemand and Darwin were incorporated in a resolution passed by the association. At the suggestion of Darwin the resolution, as passed, also definitely recognized that observations of the direction of gravity, that is of deflections of the vertical, may also be used in determining the isostasy or rigidity of the crust of the earth, as well as observations of the intensity of gravity.

Nearly all of the party lived at the same hotel. Numerous social functions also kept the party together and served to make the delegates acquainted with each other. Among the social functions were a reception by the Archduke Josef, at the Royal Palace, a dinner given by the city of Budapest, a dinner given by Count Apponyi, the Minister of Public Instruction, an informal dinner given by the delegates in honor of their entertainers, an evening of Hungarian opera and several afternoon excursions.

The surroundings in which the conference met were especially interesting. It is a surprise to find that Budapest, the Hungarian capital, is a rapidly growing modern city, with all modern improve-

ments. One finds in it an intense national life and, at the same time, many interesting evidences of the influence of several different civilizations. Eleven different languages are officially recognized by being printed upon the paper money.

O. H. TITTMANN,
JOHN F. HAYFORD.

SCIENTIFIC BOOKS.

Mars and its Mystery. By EDWARD L. MORSE. Boston, Little, Brown and Company. 8vo. Pp. 192.

This book is distinctly a plea for the existence of intelligent inhabitants upon our sister planet, the argument being based largely on the observations of Professor Lowell at Flagstaff, Arizona. The author begins by pointing out that because a man is an astronomer, this fact by no means qualifies him to act as a judge upon a question of this sort. It is doubtless true that astronomers as a rule know little of the appearance of the surface of Mars, and but few of them have ever seen it under favorable conditions. Nevertheless, it must be admitted that a man who is familiar with the difficulties of telescopic observations, under varying atmospheric conditions, would be a better judge of the value of telescopic evidence than one who had never looked through a telescope, and took it for granted that the planet looked exactly as it is drawn on paper.

A large part of the book is devoted to an examination of the views of various astronomers and amateurs as to the interpretation of the various markings seen upon the planet's surface. The book is marred in one or two places by a rather savage personal attack upon a British astronomer in good standing, partly, apparently, on account of his religious convictions! Considerable attention is paid to the appearance of various systems of natural cracks, such as appear in pottery, dried mud, and the surface of the moon. Two interesting plates are given, in which these are compared with maps of railway systems, canals, and the markings upon Mars. The argument is drawn that the last look, and are distributed, much more like the artificial than like the natural lines. Whether such is the case or not, the critic will be likely to ask "But would the markings on Mars, if we could see them well, really resemble the drawings that Professor Morse publishes of them?" This is the very *crux* of the whole question, and until this has been definitely decided, most astronomers will consider the existence there of intelligent inhabitants as unproved, although perhaps not impossible.

The main and generally accepted facts relating to the planet's surface are briefly stated, and are followed by an interesting and rather amusing account of the author's own difficulties in seeing even the well-known and most clearly defined markings of the planet. He certainly had much more difficulty than would have been expected, considering the careful training of his eye in his own professional work.

One of the most interesting chapters of the book is that devoted to the discussion of the variety of conditions under which life exists upon the earth. Here our author is more nearly on his own ground, and states a number of interesting facts, many of which it is safe to say will be new to the majority of his readers. From them he argues that the slightly dissimilar physical conditions that exist upon Mars would not interfere with the existence there of life in some of its various forms, such as we know it upon the earth.

In closing, it may be said that the book is interesting, and well worth reading to all those who wish to learn the opinions of various authorities on the most fascinating of all the planets.

WILLIAM H. PICKERING.
HARVARD COLLEGE OBSERVATORY.

First Course in Zoology. A text-book for secondary schools, normal schools and colleges. By THOMAS WALTON GALLOWAY, Ph.D., Professor of Biology in James Millikin University. P. Blakiston's Son and Company.

This book adds another to the list of text-books in zoology, of an elementary nature, which have appeared within the past half dozen years, and is indicative of the growth