Hann's dynamical theory, instead of Ferrel's convectional theory of extra-tropical cyclones, being adopted. All those regions whose precipitation is in large part dependent on extra-tropical cyclonic storms would under these conditions have an increased annual rainfall; and the lakes of interior basins in temperate latitudes would consequently increase in volume. The winter rains of subtropical belts, such as the northern Sahara, would extend further towards the equator, for the equatorward migration of the tropical belt of high pressure in winter is essentially a result of the increased vigor of the circumpolar circulation at such times; thus the formerly greater rainfall indicated by the desert *wadies* might be explained. The coincidence of greater precipitation during the same epochs of time over the glaciated, the lacustrine and the desert areas is, however, not yet independently proved.

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*GRAVITY MEASUREMENTS.**

RELATIVE measurements of the force of gravity were made in 1894 by the U. S. Coast and Geodetic Survey at twenty-six stations, mostly located along the thirty-ninth parallel from the Atlantic coast to Utah. Points were included on the Atlantic coast, Appalachian mountains, central plains, Rocky mountains (including the summit of Pike's Peak, 14,085 feet in altitude), western plateaus, and the eroded valleys of the Green and Grand rivers. The half second pendulum apparatus designed by Dr. T. C. Mendenhall was used, with methods not before employed with short pendulums. They were swung at a low air pressure (60 mm.), each swing lasting eight hours, and the successive swings covering the entire interval between the first and last time observations, usually forty-eight hours. The two chronometers used were rated by star observations made with a portable transit in the meridian. The flexure of the support was measured and correction applied. The results indicate the entire elimination of errors due to diurnal irregularities of rate, and show that there was practically no wear of the agate knife-edge. Determinations made at the base station (Washington) several times during the year show a range of only .000,004 second in the mean period of the three pendulums, indicating a high permanency of period, and throwing some light on the invariability of gravity. The average time required per station was slightly over five days.

Values of gravity for Washington derived relatively from absolute determinations made in various parts of the world show a considerable discordance, the range being from 980.047 to 980.285 dynes. The results of the past season are based on a provisional value adopted for Washington. As they were carried out with the same instruments and uniform methods, it is probable that their relative accuracy is much higher than that of many of the absolute measures.

The results are discussed principally in connection with the question of reduction to sea level, the distribution of the stations with respect to an unusual variety of continental conditions rendering the series valuable in this connection. This is an important question in the application of pendulum observations to the geodetic problem of the earth's figure, and involves the various theories as to the condition of the

* 'Results of a Transcontinental Series of Gravity Measurements,' by G. R. Putman, read February 2, 1895, Philosophhical Society of Washington, Bulletin Vol. xiii.; preliminary results were presented before the National Academy of Sciences by Dr. Mendenhall, November, 1894. Mr. G. K. Gilbert, of the U. S. Geological Survey coöperated in this work by making a geological examination of the stations. His conclusions and a discussion of the results in connection with the theory of isostasy are published in the same Bulletin.

earth's crust. It has given rise to many diverse opinions, and the apparent anomalies in the force of gravity have been so great with various methods of reduction as to necessitate the rejection of certain classes of stations even in the most elaborate discussions, as those of Clarke and Helmert. Three methods of reduction were applied to these stations, and the effect of latitude was eliminated by comparison with a theoretical formula based on Clarke's figure of the the earth. In each of these methods correction was made for the elevation above sea level and for topographical irregularities near the station, and they differ only in the allowance made for surface attraction, as follows:

1. Bougner's reduction. The vertical attraction of the entire mass above sea level was subtracted. With this method the results show a large defect of gravity on the western mountains and plateaus, closely proportional to the average elevation, but having no relation to the altitude of the particular point of observation or to distance from the ocean.

2. Elevation reduction. No correction was made for attraction. The defect of gravity in general disappears, but there are large residuals in the mountainous regions, gravity being in excess at stations above the average level of the surrounding country, and in defect at those below. The size of the residuals is nearly proportional to the difference in elevation between the station and the average level.

3. Faye's reduction. On the theory that the surface of the earth is in general in a condition corresponding to hydrostatic equilibriun, M. Faye proposed that no correction be made for the attraction of the average mass above sea level, but that account be taken of local deviations from the average level, as, for instance, the attraction of a mountain on a station at its summit. Developing this idea we may consider that all general continental elevations are compensated by a lack of density or other cause below sea level, but that local irregularities of surface are not so compensated, but are maintained by the partial rigidity of the earth's crust. The measure of this lack of compensation will be the attraction of a plain whose thickness is the difference in elevation between the station and the average surrounding country. The latter was estimated within an arbitrarily adopted radius of 100 miles of each point, and the correction applied, positive for stations below the average and negative for those above.* With this reduction all the large residuals disappear. For the fourteen stations (in mountainous regions) where it was applied, the sums of the residuals are: with Bougner's reduction 2.577 dynes, with elevation reduction 0.677 dynes, with Faye's reduction 0.175 dynes, indicating a decided advantage for the latter.

A similar discussion made of former Coast and Geodetic Survey observations on oceanic islands and coasts shows that the excess of gravity that has been found on islands with Bougner's reduction largely disappears on the application of Faye's idea, subtracting the attraction of islands considered as displacing sea water. The residuals with Bougner's reduction are probably a measure of the lack of density below sea level, and with the elevation reduction a measure of the lack of compensation. The general conclusion is that the so-called anomalies of gravity may be largely accounted for on general principles, and that the value of these measurements in connection with the problems of geodesy and the intimately related questions of terrestrial physics will be proportionately enhanced.

By comparing the values of g measured on the summit and near the base of Pike's Peak the value 5.63 was deduced for the

*Mr. Gibert independently applied this method of reduction, using a radius of 30 miles.

mean density of the earth. The attraction of the mountain was computed from contour maps and from information as to its density furnished by Mr. Whitman Cross of the U. S. Geological Survey. A set of quarter-second pendulums designed by Dr. Mendenhall was tested at four of the stations with satisfactory results. This is the smallest apparatus yet made for the purpose, weighing but 106 pounds with packing boxes.

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THE ASTRONOMICAL AND PHYSICAL SOCIETY OF TORONTO.

THIS Society, now very widely known, was originally formed in 1884 by a few gentlemen who, while actively engaged in business pursuits, were kindred spirits in their love for scientific study and met at intervals more or less regular at their respective residences for recreative reading, observation and experimentation. The membership gradually increasing, it was finally decided to secure incorporation under a general Act permitting the acquiring and holding of real and personal property, etc., and in 1890 the Society became a corporate body. The first president of the new association was the late Mr. Chas. Carpmael, M. A., F. R. A. S., the Director of the Toronto Magnetic Observatory; the vice-president was Mr. Andrew Elvins, who had indeed been the first to gather together the few friends who had formed the original nucleus, and who is still highly esteemed and honored as the father of amateur astronomy in Toronto. A constitution modeled upon that of the Astronomical Society of the Pacific having been framed and by-laws adopted, a circular was addressed to many scientific societies and distinguished astronomers and physicists throughout the world. Several of the latter became corresponding members, while various scientific bodies contributed many volumes of reports, etc., which formed the beginning of what is now a very valuable library. Without this very material aid the progress of the Toronto Society would have been very slow indeed, but as, at meeting after meeting, the secretary's and librarian's reports were read, it became soon apparent that the heartiest sympathy and support were being extended, without exception, by all who had been addressed.

The first annual report of the Society was an unpretentious little volume of 40 pages, containing abstracts of papers read during the year 1890, and records of the more important work done at the telescope by the various members who were particularly interested in observation. The frontispiece was a drawing of sun-spots and also of hydrogen flames, by Mr. A. F. Miller, who has always taken a keen interest in solar physics. Mr. T. S. H. Shearmen contributed a paper on 'Coronal Photography, in the Absence of Eclipse.' In common with many other enthusiastic observers, Mr. Shearmen is still engaged upon this work. Referring to the objection raised regarding the impossibility of photographing the corona in full sunshine on account of the very slight difference between the intensities of the two lights, Mr. Shearmen cites observations of the inferior planets seen projected on the corona.

The appendix to this volume contains a list of the presents donated by the various observatories and scientific bodies in the United States, and by Mr. John Goldie, of Galt, Ont., a life member of the Society. The list of the Society's exchanges increased very rapidly after the publication of the first report. The volume for 1891 contained papers by Dr. J. Morrison, Mr. J. Ellard Gore and Mr. W. F. Denning. An opera-glass section had been formed which met during the weeks alternating with the regular fortnightly meetings of the Society, and much interest