ence, and a catalogue of its publications. The volume originally appeared as one of the sections of the commemorative album which was issued as a memorial of the fiftieth anniversary of the foundation of the "Colegio de Belen" in Havana. The purpose for which the monograph was prepared made a popular treatment of the subject imperative, and the result is a most happy one.

Within four years after the establishment of the "College" in Havana, the Observatory was decided on, and a year later, in 1858, a regular system of meteorological observations was commenced under the supervision of Father Antonio Cabré, S. J. In 1870 Father Benito Viñes was appointed Director, and the record of the twenty-three years of his administration is the story of a noble life devoted to scientific research, with the grand object held in view to force from nature the key to the laws controlling the course and premonitions of the most dreadful of all storms—the West Indian hurricane. The importance of these problems to this section of the globe can be inferred from the statement quoted, that Señor Poey had collected notices of three hundred and sixty cyclones which had visited the Antilles in three hundred and sixty-two years, the devastation wrought by many of them being beyond description.

The Observatory of the Belen College has been founded, equipped, and sustained, except as hereafter noted, from its inception to the present day exclusively at the expense of the College. Its personnel, instruments, regular publications for free distribution, as well as the special works on hurricanes which are for sale, all have been supplied at the cost of the Institution. The only exceptions to the above are the contributions from various commercial bodies and a single grant from the Spanish Government of the Island of Cuba. In 1896, in response to the recommendation of the representative authorities and bodies of the island, the Colonial Minister notified the Director of the Observatory that the Spanish Government had approved of a subvention of 15,800 pesos annually for the support of the Observatory. Of this grant the Observatory received 10,000 pesos, and then the demands made by the Revolution and consequent war with the United States stopped all further revenue from this source.

In connection with the meteorological work a magnetic observatory has been maintained since 1862. J. E. McGrath.

U. S. Coast and Geodetic Survey.

MAGNETIC SURVEY OF JAPAN FOR EPOCH 1895.[1]

Volume XIV of the Journal of the College of Science of the Imperial University of Tokio is devoted to the publication, in great detail, of the results of the magnetic survey of Japan, made during the four summers, 1893-6, under the authority of the Earthquake Investigation Committee.

[1] A Magnetic Survey of Japan reduced to the epoch 1895.0 and the sea level, carried out by order of the Earthquake Investigation Committee. Reported by A. Tanakadate, Professor of Physics, Imperial University, Tokio. The Journal of the College of Science, Imperial University of Tokio, Japan. Vol. XIV, 1904. 8vo. Pp. xii, 180 (347), 98 plates, including 11 maps.

The first part of the report, pages 1-180, gives the general plan of the work, the instruments and methods employed in the field, and the discussion of the results. Then follow, pages (1) to (347), the observations themselves in detail. Finally there are three series of plates (Nos. I to XCVIII), one showing graphically the observed diurnal variation of declination at each station and the mean value for the day deduced therefrom, the second giving a topographic sketch of each station, and the third consisting of a set of iso-magnetic maps.

Fifteen different observers took part in the work, most of them being professors in the Imperial University or other educational institutions of Tokio. Two parties were in the field during each of the first three summers, and three during the summer of 1896. There were from two to four persons in each party, all trained to do any part of the work. A season's work lasted, on the average, a little over three months. In all 320 stations were occupied, several were occupied more than once, and in several localities subordinate points were occupied to test for local disturbances. The average distance between stations was about 40 kilometers (25 miles).

The magnetometers used were of the same type as the one used by the South Party in the magnetic survey of 1887, and fully described in Vol. II, p. 178, and Vol. V, p. 163, of the Journal of the College of Science. The declinometers were of the electro-magnetic type, four positions of the coil being taken in each set of declination observations. The cylindrical form of magnet was adopted, and a "transporter" was devised by means of which the magnet could be changed from one position to another on the deflection bar without being touched by hand. For oscillations the magnet was suspended by a double loop of silk fiber without the usual stirrup. So it was possible to determine the moment of inertia of the magnet directly by measurement, as well as by the use of an auxiliary inertia bar. The magnet was suspended in the dip circle box during oscillations. The dip circles were of the ordinary Kew type, and made by Casella. For reversing the polarity of the dip needles, a closely-fitting pair of coils and a dry battery were provided. The constants of the magnetometers were determined at various times during the progress of the survey, and comparisons of the various instruments were made, but they were not considered sufficiently extensive to warrant an attempt to reduce all the observations to some standard instruments.

The astronomical meridian was usually found by observations of Polaris. Then the transits of six stars were observed for the determination of azimuth, collimation, and clock errors. Declination was observed at as many times during the day as possible. Dip and horizontal intensity observations were usually made three times during the day, and a set was often made at night after the completion of the astronomical work.

It was hoped to obtain the means for reducing the observations to a common epoch by reoccupying as many as possible of the stations of the survey of 1887. It was found, however, that observations at most of the old stations were impracticable on account of changes in the surroundings, only seven being exactly reoccupied. Moreover, three destructive earthquakes occurred between the earlier survey and the end of the present, the most severe one in 1891. Consequently it was decided to determine the secular variation by comparing the empirical formulæ expressing the three elements in terms of the latitude and longitude as derived from the two surveys, corresponding to the dates 1887.61 and 1895.12, the variations being assumed uniform during that interval. The values of annual change thus derived were used to reduce all the observations to the same epoch 1895.0. Corrections were also applied to reduce to sea level.

From the results thus corrected two sets of isomagnetic maps were prepared, one obtained by graphical interpolation after platting the observed quantities on a map, and showing to some extent the local irregularities in the distribution of the magnetic elements, the other by deducing empirical formulæ involving the first and second powers of the latitude and longitude, and thus representing the general distribution over the whole country. This second set of maps includes those for the total force and westerly, northerly, and vertical components, as well as declination, dip, and horizontal intensity. Two tables are given, one showing the agreement between the values of declination, dip, horizontal intensity, and total intensity resulting from observation and the values computed from the empirical formulæ, and the other making a similar showing of the values of the X, Y, and Z components, and deducing therefrom the amount and direction of the residual force for each station. The differences between the observed and computed values of the magnetic elements give for the average probable error of a single result $\pm 6'.5$ for declination, $\pm 5'.5$ for dip, and $\pm 73\gamma$ for horizontal intensity. These values are to be ascribed to local disturbances, rather than to errors of observation.

In investigating the vertical currents of electricity, Tanakadate first took the line integral around the periphery of the country. This method proved unsatisfactory, however, both because it gave only an average value for the whole country and no idea of differing current densities in different parts of the country, and because along the borders of the country the empirical formulæ give the least reliable representation of the isomagnetic lines as they really exist. By transforming the line integral into surface integral, he was able to determine the vertical current for points at the intersection of meridians and parallels for the entire country. For the purpose of comparison he made the same computation for Great Britain and for Austria, using the results of the surveys of Rücker and Thorpe and Liznar. All three surveys give a line of no current through the middle of the country; in Japan the current is upward on the Pacific side and downward on the Siberian side; in Austria it is upward on the north and downward on the south; in Great Britain, upward on the east and downward on the west. The author thinks it very doubtful, however, whether the distributions of currents thus indicated actually exist, and that much more elaborate surveys will be required to enable one to draw any definite conclusions.

Various investigators have attempted to deduce the variation with altitude of the magnetic elements from observations made at different elevations. The local disturbances to be expected on mountains, where observations must be made in order to secure sufficient difference of elevation, are so much greater than the probable effect of difference of elevation, that little can be expected from this treatment of the subject. Tanakadate attacks the problem from the mathematical side. By assuming the electric currents flowing in the atmosphere to be negligibly small, he derives a set of equations expressing vertical variations of the rectangular components of the Earth's magnetic force in terms of their horizontal variations and, by transformation, in terms of the magnetic elements and their horizontal variations. After computing the vertical variations of the rectangular components in this way, the vertical variations of the elements themselves may be obtained. Thus the reduction to sea-level, referred to above, was computed for each station. The resulting corrections are so small, well within the probable error of observation, that the labor involved in computing them seems out of all proportion to the improvement in the results, even if the assumptions upon which the formulæ are based be valid. This is especially the case with the survey of Japan, where very few of the elevations exceed one kilometer, and by far the greater number are less than one-fourth of a kilometer. Moreover, in countries where greater elevations are involved, the local disturbances to be expected are much greater than the corrections to reduce to sea-level, as the author himself points out.

Tanakadate makes an elaborate investigation of the effect upon the vertical variation of the magnetic force which may be expected from a simple disturbing force acting upon a uniformly magnetized sphere. Applying the results of this investigation to the computed vertical variations in Japan, he finds that roughly a disturbing force of —.138 C. G. S. units located 1000 km. below the surface in latitude 34°N and longitude 116°E is demanded. This agrees, as Tanakadate points out, with Bauer's investigation of the residual field of the Earth's magnetism in this Journal, Vol. IV, p. 44, where a center of attraction is located in latitude 35°N and longitude 110°E, with a residual vertical intensity of —.139 C. G. S. units (*i. e.*, directed downward). He questions the existence of such a disturbing force, however, since recent observations in Central China exhibit no such anomalies in the vertical variations as would be produced by it. DANIEL L. HAZARD.

U. S. Coast and Geodetic Survey.

MAGNETIC SURVEY OF BRAZIL.

The semi-annual report[1] of the Meteorological Bureau of the Navy Department of Brazil, for the period April to September, 1903, announces the beginning of a magnetic survey of Brazil. A field party began work in the northern part of the country in August, 1903, and results may be expected in the report covering the succeeding six months.

The Bureau continues its observations at Rio de Janeiro as heretofore, declination nearly every day, dip twice a week, and horizontal intensity once a week. The results for the first six months of 1904 and for the corresponding period of 1903 are as follows:

Date	Declination	Inclination	Horizontal Intensity	Total Intensity
			γ	γ
Jan.-June, 1903	8° 24′.8 W	13°.56 S	24810	25520
Jan.-June, 1904	8 35 .3 W	13 .67 S	24810	25532

[1] Boletim Semestral dos resultados obtidos na Estação Central no Morro de Santo Antonio (Rio de Janeiro) durante o semestre decorrieo de Abril a Setembro de 1903. Director de Meteorologia AMERICO SILVADO, Capitao-Tenente. Rio de Janeiro, Imprensa Nacional, 1904.

It is expected that some of the vessels of the Navy will be provided with small portable magnetic instruments, and then the officers who have acquired practice in observing at Rio de Janeiro can determine the magnetic elements at whatever port the ships may touch.

Attention is called to the difficulty of properly compensating ships' compasses at a place so near the magnetic equator as Rio de Janeiro; on account of the small magnitude of the vertical force, that part of the induced magnetism of the ship which is a function of the vertical force is so nearly zero as to require no compensation. When the ship goes to a high magnetic latitude, however, large deviations may be expected, due to the increased vertical force.

The observatory at Rio de Janeiro has recently been supplied with a large Brunner declinometer, which will take the place of the Elliott magnetometer heretofore in use and leave the latter available for carrying on the magnetic survey. The Observatory will also be supplied with a dip circle of similar dimensions. DANIEL L. HAZARD.

PROFESSOR BENNETT'S NEW METHOD OF REPRESENTING THE DEVIATION OF THE COMPASS.

In the Journal of the Royal United Service Institution for January, 1905, Professor G. T. Bennett, of Emmanuel College, Cambridge, gives a new graphical method for the determination of the deviation of the compass for any direction of the ship's head.

This method has for its foundation the linear equations of Poisson which give an analytical expression of the forces acting on the compass needle of an iron ship, in terms of the terrestrial magnetic force. Being interpreted geometrically, the forces expressed by these equations are represented by two vectors connected by projective relations.

Taking a circle for a compass diagram, any course, whether reckoned from the direction of the magnetic north or from the direction of the disturbed compass needle, is marked on the circumference at the proper angular distance from the north point. To designate corresponding compass courses and magnetic courses Professor Bennett uses the same letter with the appropriate subscript c or m. Thus N_c represents the compass course due north while N_m represents the magnetic north.

Two opposite compass courses are situated at the extremities of a diameter while the line joining the two corresponding magnetic courses does not pass through the center of the circle, but lies to one side and is called a magnetic chord. On account of the projective relations previously mentioned, the magnetic chords all meet in a point.

The two lines determined by joining the points representing two pairs of opposite compass courses together with the two corresponding magnetic chords form a quadrilateral, and of the two diagonals of this quadrilateral the one which does not pass through the vertex of the quadrilateral that is always formed at the center of the compass-circle is called the *working diagonal.*

The lines determined by two pairs of opposite compass courses and their corresponding magnetic chords form a single parallelogram. Those deter-

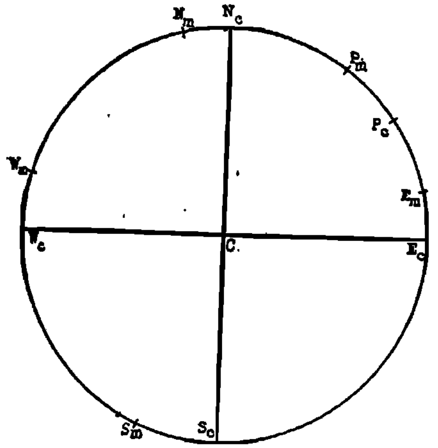

Fig. 1

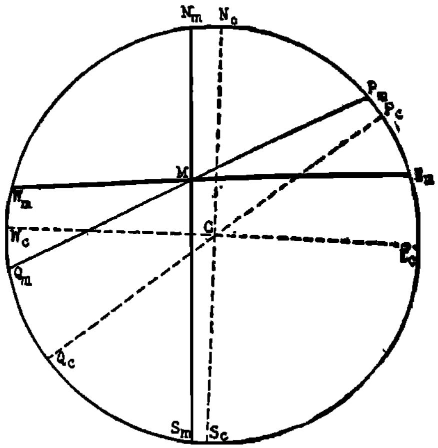

Fig. 2

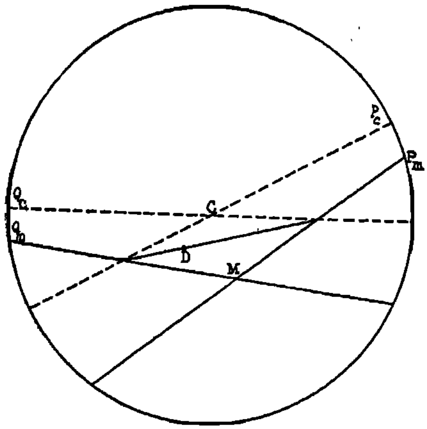

Fig. 3

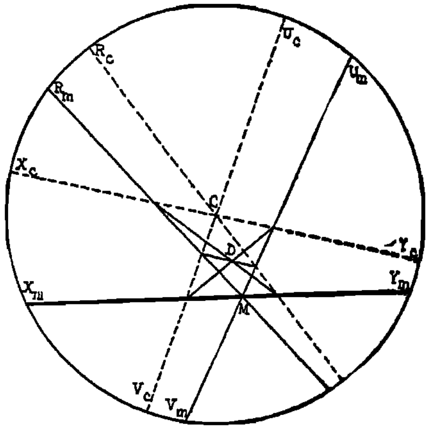

Fig. 4

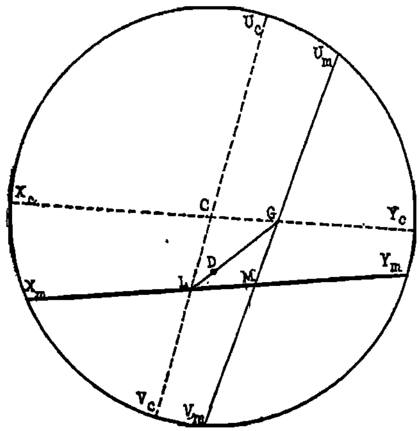

Fig. 5

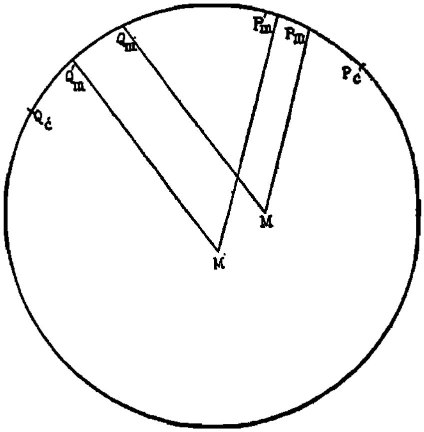

Fig. 6

mined by three pairs of opposite compass courses and the corresponding magnetic chords form three parallelograms, and similarly for lines determined by four such pairs of opposite courses six parallelograms are formed. In general the lines determined by n pairs of opposite compass courses and their corresponding magnetic chords form as many parallelograms as there are combinations of n things taken two at a time or $\dfrac{\underline{|n}}{\underline{|2}\;\underline{|n-2}}$.

On account of the projective relations existing between the lines determined by compass courses and their corresponding magnetic chords, all the working diagonals meet in a point.

Referring to the six figures annexed, let the point where the magnetic chords intersect be designated as M, and the point where the working diagonals meet be designated as D. Observations on any two pairs of opposite compass courses are sufficient to find M, and observation on any other compass course enables us to determine three working diagonals of which the intersection of any two determines D.

M and D being found, let it be required to find any compass course as X_c, corresponding to a given magnetic course X_m. Let MX_m meet CU_c in L, and let LD meet MU_m in G. GC meets the circle in the required point X_c. The compass course X_c being given, the magnetic course X_m may be found similarly.

Let $X_c C$ intersect MU_m in G, and extend GD until it intersects $U_c C$ in L and draw ML and extend it till it intersects the circle in X_m.

The quadrantal deviation of the compass produced by the iron of a given ship remains constant in all parts of the world, and consequently the constancy of the direction of all magnetic chords is maintained; but the semicircular deviation changes with a change of latitude and this causes the points M and D of the diagram to shift their positions. This changed position of M can be determined from observations of deviation on any two compass courses. If P_m and Q_m corresponding to the compass courses P_c and Q_c respectively change to P'_m, Q'_m on changing latitude, then lines through P_m, Q_m respectively parrallel to P_mM and Q_mM will intersect and determine M'.

Professor Bennett also discusses some relations existing between his diagram and the "*exact coefficients*" of the deviation formula, and opens up an interesting field for experiment.

G. W. LITTLEHALES.

U. S. Hydrographic Office, Washington, D. C.