USE OF THE BAROCYCLONOMETER.

If an observer after consulting the given data and rules has satisfied himself of the approach of a cyclone, he must (by turning the projecting knob) set the central arrow of the wind disk in the mean direction of the tracks followed by the cyclones of the region during the respective seasons. For this purpose the mean trajectories followed by the typhoons during the various months of the year have been laid down in the large map accompanying this book. The instrument is now ready for approximately indicating the position and direction of the center.

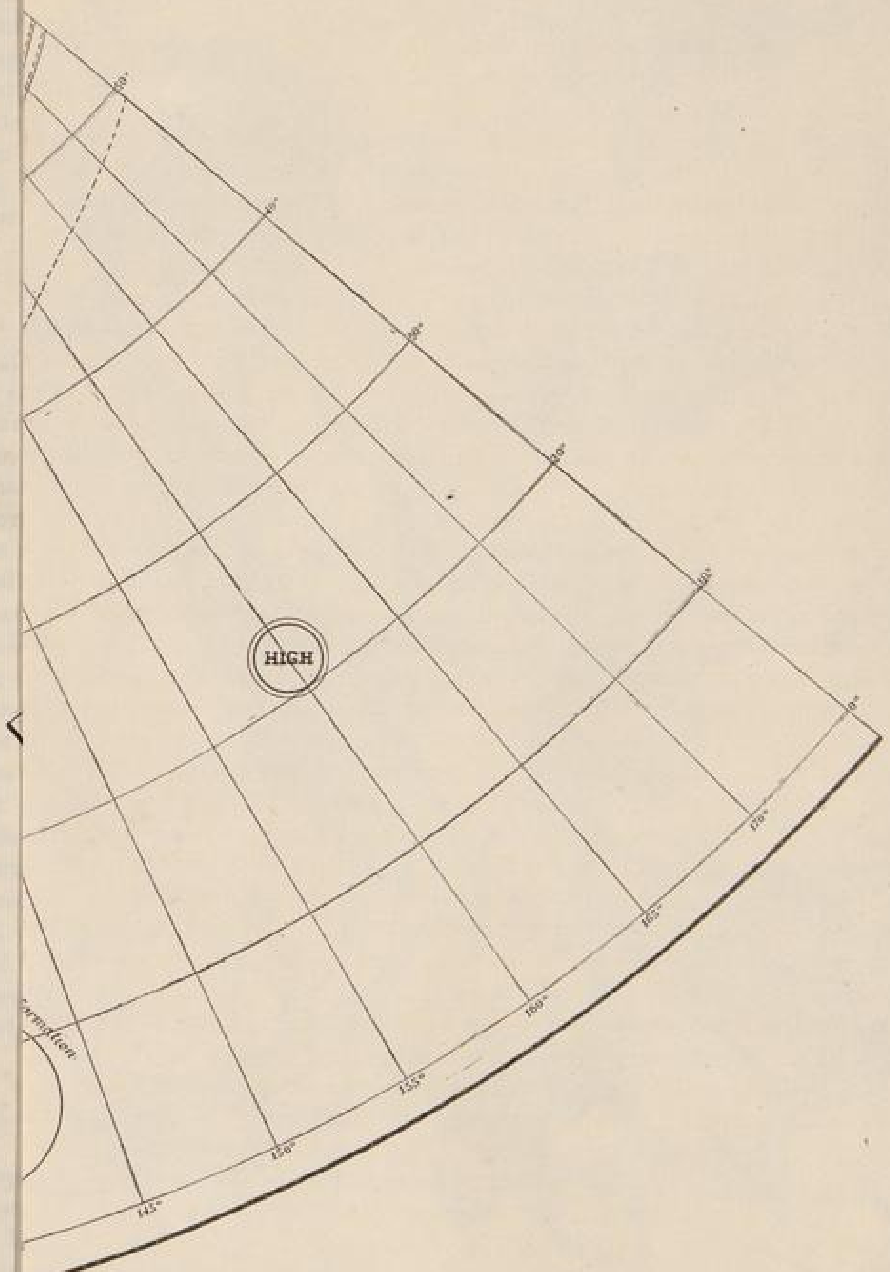
The first approximation.—The observer must get accustomed to imagining himself placed according to the state of the barometer and the direction of the wind at a point of the concentric rings of the wind disk; this will in no small degree facilitate his calculation. In order to arrive at a first approximation as to the whereabouts of the storm, we must note which of the wind arrows represented in zone A corresponds to the direction of the wind prevailing at the place of observation.[1] If none of the arrows actually drawn corresponds exactly to this wind direction, it will not be difficult to find the place of the ring where the arrow ought to lie. Having found the wind arrow, we must set one of the two large needles in such a way that the plain end of it passes through the starting point of the arrow on the circle; the other end of the needle will then point toward the direction in which the center lies.

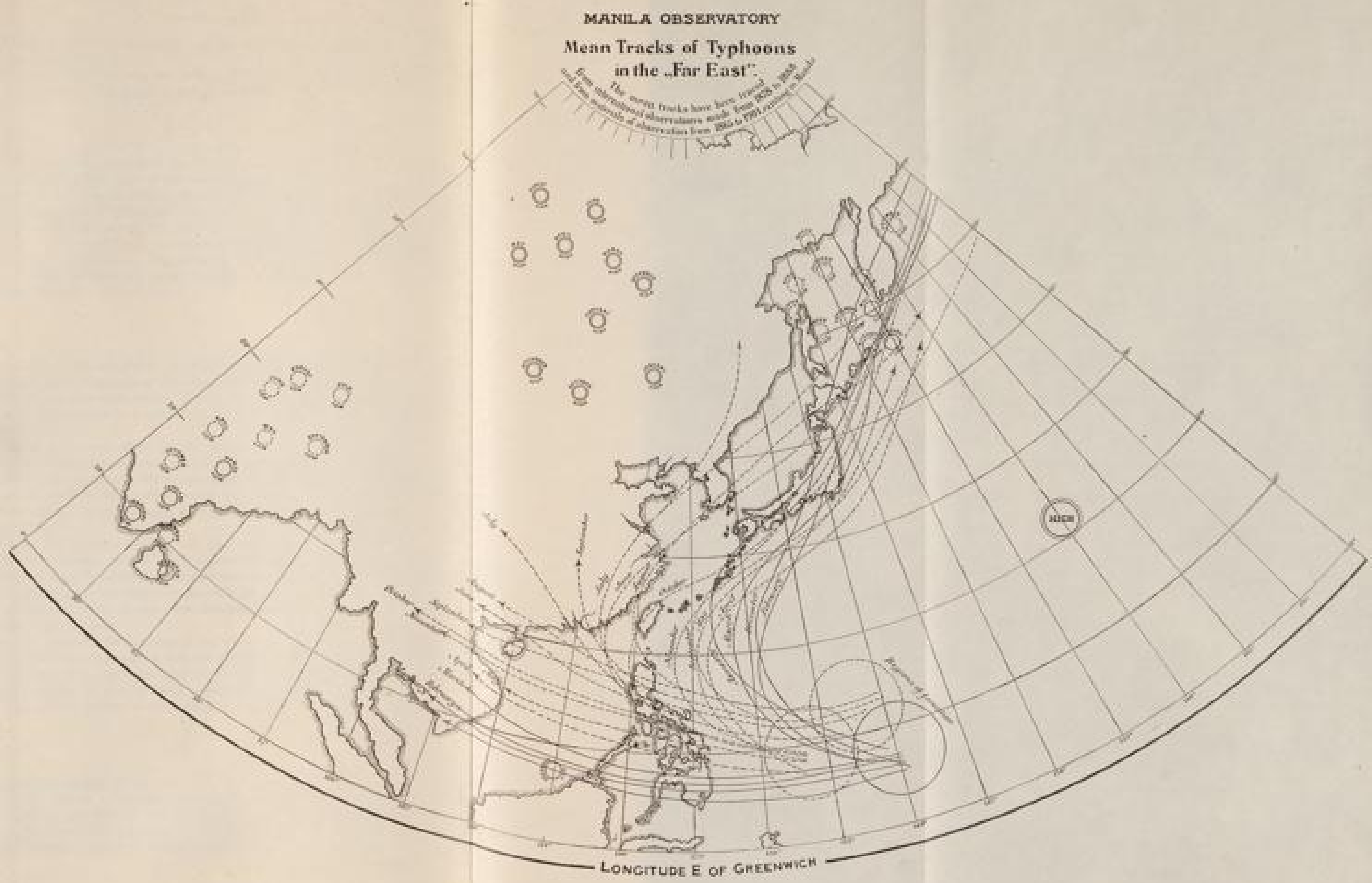
If the barometer falls, even though slowly, or if there is a partial change in the barometrical curve but the wind is still blowing from the same point or from a direction close to it, this is a proof that the position of the center has been determined with sufficient accuracy. In proportion as the barometer keeps on falling, the indications given by the wind direction will be more reliable.

The second approximation.—If by a further fall of the barometer and by a partial change in the daily range of pressure the barometrical reading already corresponds to the ring for zone B, we must determine the prevailing direction of the wind and find out the wind arrow in ring B which corresponds to this direction of the wind. Next we must bring the needle to cut the wind arrow at its starting point, as before, then the other end points with greater certainty than before toward the direction in which the center lies. If the wind veers we must repeat the operation. If the wind veers without a total change in the daily curve of the barometer taking place, we may take it for granted that the center will not pass over the place of observation. The instrument shows the observer with sufficient accuracy for practical purposes not only the direction in which the center lies but also—and this is for the sailor most important—the distance of the center and the direction in which it is most probably moving.

The third approximation—The determination of the direction of the center.—If the barometer keeps on falling, the observer determines the prevailing wind direction as before, searches for the corresponding wind arrow and, using now the double needle, brings its single end to cut the wind arrow as before. The end to which the small needle is fastened shows the position of the center. If the wind continues to blow from the same point and the barometer keeps on falling we need not proceed further; the center is approaching the place of observation exactly from the direction which the needle indicates. If, however, the wind direction in two or three hours changes, then we must repeat the observation with the graduated needle, leaving the double needle un-

[1] With regard to all the applications of the barocyclonometer it is important to remember that, in speaking of wind directions, the direction of the *prevailing* wind is meant, not that of passing gusts and squalls the directions of which are often misleading, especially near the outermost parts of the typhoon.


HIGH
145°
150°
155°
160°
165°
170°


MANILA OBSERVATORY
Mean Tracks of Typhoons
in the „Far East".
The mean tracks have been traced
HIGH
LONGITUDE E OF GREENWICH

touched; we can then by the aid of Fournier's rule find by calculation the direction of the center's advance with sufficient accuracy.

According to Commander Fournier the following proportion expresses the relation between the descent of the barometer within a cyclone and the distance of the center—

$$\frac{P-P_2}{P-P_1}=\frac{D_1}{D_2}.$$

Here P is the atmospheric pressure at the outskirts of the storm, P_1 and P_2 are the heights of the barometer at two different times of observation, D_1 and D_2 the distances of the vortex at the respective moments. P may be taken from the table given on page 7, while P_1 will be the barometer reading at the time of setting the double needle for third approximation, corrected, if necessary for daily oscillation, and P_2 the reading when the graduated needle is set eventually similiarly corrected. $P-P_1$ and $P-P_2$ are consequently easily found. But in order to solve the problem we must know a third term. Not necessarily, because the *absolute* values of the distances do not affect the *direction* in which the center is moving; this direction depends upon their *relative* values and the included angle. But we know—

$$\frac{D_1}{D_2}$$

since the terms of the left side are given. In order to arrive at numerical results we assume D_1 divided into 100 equal parts, thus making it a numerical constant, though the unit by which it is measured may vary within very wide limits. The solution of the proportion will now give us the proportional value of D_2 expressed in a number of the equal parts of D_1, which number may be greater or less than 100.

In the apparatus D_1 is represented by the distance of the pivot of the small needle from the center of the wind disk, which distance, as will be remembered, equals the graduated portion of the other needle=100. Having therefore calculated D_2 from the above proportion, all that is necessary is to set the small needle in such manner that it points to that division line of the graduated needle whose ordinal number is equal to D_2, then the small needle will be parallel to the trajectory of the cyclone.

Corresponding to this direction we turn the disk of the cyclonometer until the central arrow is parallel to the small needle. Should the barometer continue to fall rapidly, it will be very advisable to repeat the whole operation, taking now into consideration the wind directions given for zone C or D. But there is an imperative necessity of repeating the third approximation as often as the *prevailing* wind veers; it may prove disastrous to wait until the wind has run through two or three points of the compass.

It may be well to point out the meaning of the whole procedure. The problem of determining the direction of the trajectory resolves into the following: Given one angle of a triangle and the proportion of the two including sides: find the direction of the third side. The two determinations of the center's bearing, the first of which is laid down on the wind disk by the position of the double needle and the second by that of the graduated needle, give us the included angle, while the fraction—

$$\frac{P-P_2}{P-P_1}$$

furnishes the proportional lengths of the sides. D_1, represented by two-thirds of the half-length of the double needle, having a constant *numerical* value equal to 100 (whatever its linear magnitude may be), we calculate D_2 and lay it off on the graduated needle by pointing the small needle at the corresponding division of the graduated end, which manipulation brings the small needle into a position parallel to the line whose direction is sought—that is, the trajectory of the typhoon.

The determination of the direction of the progressive movement being founded upon mean values, the result is essentially approximate. But there is still another source of inaccuracy. The equation—

$$\frac{P-P_2}{P-P_1}=\frac{D_1}{D_2}$$

states that the decrease of atmospheric pressure from the outer limit of a typhoon to any two points within it is inversely proportional to their distances from the center. There can be no doubt that this assertion is not rigorously true. Still in actual application the error is found to be sufficiently small to give results which have all the accuracy required for practical purposes.

Correction for daily oscillation.—Above we stated that the barometer readings, P_1 and P_2 should be corrected for daily oscillation *if necessary*. For this purpose we give a set of tables containing the mean corrections to be added (algebraically) to these readings, if it is desired to correct them. The tables (pp. 15–19) have been compiled from the records of the observatories of Manila, Hongkong, Zi-ka-wei, Tokio, and Nemuro, and consequently cover the seas most exposed to typhoons. From them the observer can select the one corresponding to his latitude.

Theoretically there can be no doubt that these corrections are required, because the formula—

$$\frac{P-P_2}{P-P_1}=\frac{D_1}{D_2}$$

in which P is a constant mean value, supposes the differences $P-P_1$ and $P-P_2$ to express the barometric fall due to the cyclone. The actual reading, however, gives the combined effect of the cyclone and the daily oscillation, though the latter may be *hidden* by the overwhelming influence of the former.

But practically these corrections will rarely be of great importance. The tables give as *extremes* +1.8 millimeters (0.070 inch) and —1.4 millimeters (—0.056 inch). A glance at the formula makes it clear that whenever the differences $P-P_1$ and $P-P_2$ are rather large, the application or omission of the corrections will have little effect on the resulting value of D_2. Moreover, we must not forget that the whole process is based upon mean values, hence in a concrete case it can not give rigorously exact results. Nor is this necessary. The discrepancy between the values of D_2, as obtained with uncorrected respectively corrected readings, appears chiefly in zones A and B, where the differences $P-P_1$ and $P-P_2$ are small; the nearer we approach the vortex the less the value of D_2 is affected by slight corrections. Now it is easily understood that in the outer parts of the storm a small error in the determination of the direction of the storm's track is not likely to have grave consequences. Still it will be advisable to try the effect of the corrections in zones A and B whenever they have opposite signs for P_1 and P_2, or even when they are of the same quality but the barometric fall between the two observations has been small. We will show by an example the effect which the corrections *can* have in extreme cases.

Suppose, on May 15 at 9 a. m., the barometric reading on board a steamer in the latitude of Manila is found to be 753.2 millimeters (for sea level). The wind having veered, another observation at 4 p. m. gives 747.6 millimeters. Hence the total fall is 5.6 millimeters. But is this due solely to the approach of the cyclone? By no means. During May the correction for oscillation is at Manila —1 millimeter at 9 a. m. and +1.6 at 4 p. m. Fully 2.6 millimeters of the change are therefore due to the daily oscillation.

Applying Fournier's rule to the original readings we have:

$$\frac{755-747.6}{755-753.2}=\frac{7.4}{1.8}=\frac{100}{x} \therefore x=(D_2)=24$$

But applying the same formula to the corrected readings we obtain:

$$\left.\begin{array}{l}9\text{ a. m.}: 753.2-1.0=752.2\\ 4\text{ p. m.}: 747.6+1.6=749.2\end{array}\right\} \therefore \frac{755-749.2}{755-752.2}=\frac{5.8}{2.8}=\frac{100}{y} \therefore y=(D_2)=49$$

If the wind has veered very much between the two observations, this difference in the values of D_2 and the consequent difference in the storm's direction determined therefrom may not be serious, but if the wind has changed only a few points said difference might easily prove disastrous to the steamer.

The statements concerning the effect of the corrections for oscillation are further illustrated and confirmed by the table given at the end of this section.

TABLES OF CORRECTIONS TO P_1 AND P_2 FOR DAILY OSCILLATION.

I. MANILA.

[120° 58′ east of Greenwich; 14° 35′ north latitude.]

Hour.	January.		February.		March.		April.		May.		June.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m.	—0.006	—0.2	—0.007	—0.2	—0.010	—0.3	—0.012	—0.3	—0.010	—0.3	—0.011	—0.3
2 a. m.	0.007	0.2	0.005	0.1	0.004	0.1	0.002	0.1	0.002	0.1	0.001	0.0
3 a. m.	0.017	0.4	0.014	0.4	0.011	0.3	0.011	0.3	0.010	0.3	0.009	0.2
4 a. m.	0.016	0.4	0.014	0.4	0.013	0.3	0.010	0.3	0.010	0.3	0.011	0.3
5 a. m.	0.007	0.2	0.006	0.2	0.005	0.1	0.000	0.0	0.003	0.1	0.006	0.2
6 a. m.	—0.006	—0.2	—0.010	—0.3	—0.012	—0.3	—0.014	—0.4	—0.009	—0.2	—0.005	—0.1
7 a. m.	—0.024	—0.6	—0.028	—0.7	—0.032	—0.8	—0.032	—0.8	—0.025	—0.6	—0.018	—0.5
8 a. m.	—0.042	—1.1	—0.044	—1.1	—0.047	—1.2	—0.049	—1.2	—0.036	—0.9	—0.025	—0.6
9 a. m.	—0.053	—1.3	—0.056	—1.4	—0.056	—1.4	—0.055	—1.4	—0.041	—1.0	—0.029	—0.7
10 a. m.	—0.047	—1.2	—0.054	—1.4	—0.050	—1.3	—0.047	—1.2	—0.037	—0.9	—0.026	—0.7
11 a. m.	—0.031	—0.8	—0.037	—0.9	—0.037	—0.9	—0.033	—0.8	—0.024	—0.6	—0.015	—0.4
Noon	—0.007	—0.2	—0.013	—0.3	—0.013	—0.3	—0.012	—0.3	—0.006	—0.2	—0.002	—0.1
1 p. m.	0.024	0.6	0.018	0.5	0.018	0.5	0.021	0.5	0.020	0.5	0.018	0.5
2 p. m.	0.048	1.2	0.044	1.1	0.046	1.2	0.048	1.2	0.043	1.1	0.035	0.9
3 p. m.	0.061	1.5	0.061	1.5	0.064	1.6	0.065	1.7	0.057	1.4	0.049	1.2
4 p. m.	0.056	1.4	0.061	1.5	0.067	1.7	0.070	1.8	0.062	1.6	0.052	1.3
5 p. m.	0.041	1.0	0.050	1.3	0.057	1.4	0.063	1.4	0.054	1.4	0.044	1.1
6 p. m.	0.026	0.7	0.036	0.9	0.041	1.0	0.042	1.1	0.033	0.8	0.028	0.7
7 p. m.	0.008	0.2	0.020	0.5	0.023	0.6	0.022	0.6	0.014	0.4	0.010	0.3
8 p. m.	—0.008	—0.2	0.001	0.0	0.003	0.1	0.002	0.1	—0.004	—0.1	—0.008	—0.2
9 p. m.	—0.020	—0.5	—0.014	—0.4	—0.016	—0.4	—0.017	—0.4	—0.022	—0.6	—0.024	—0.6
10 p. m.	—0.024	—0.6	—0.022	—0.6	—0.027	—0.7	—0.032	—0.8	—0.034	—0.9	—0.035	—0.9
11 p. m.	—0.022	—0.6	—0.023	—0.6	—0.030	—0.8	—0.033	—0.8	—0.035	—0.9	—0.038	—1.0
Midnight	—0.017	—0.4	—0.019	—0.5	—0.022	—0.6	—0.022	—0.6	—0.023	—0.6	—0.027	—0.7

Hour.	July.		August.		September.		October.		November.		December.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m.	—0.008	—0.2	—0.010	—0.3	—0.007	—0.2	—0.002	—0.1	—0.003	—0.1	—0.006	—0.2
2 a. m.	0.005	0.1	0.005	0.1	0.007	0.2	0.011	0.3	0.012	0.3	0.009	0.2
3 a. m.	0.013	0.3	0.014	0.4	0.016	0.4	0.019	0.5	0.022	0.6	0.020	0.5
4 a. m.	0.015	0.4	0.016	0.4	0.018	0.5	0.020	0.5	0.022	0.6	0.018	0.5
5 a. m.	0.012	0.3	0.012	0.3	0.012	0.3	0.013	0.3	0.013	0.3	0.010	0.3
6 a. m.	0.001	0.0	0.004	0.1	0.002	0.1	—0.004	—0.1	—0.004	—0.1	0.003	0.1
7 a. m.	—0.011	—0.3	—0.010	—0.3	—0.013	—0.3	—0.020	—0.5	—0.021	—0.5	—0.021	—0.5
8 a. m.	—0.020	—0.5	—0.023	—0.6	—0.029	—0.7	—0.034	—0.9	—0.036	—0.9	—0.041	—1.0
9 a. m.	—0.026	—0.7	—0.030	—0.8	—0.035	—0.9	—0.043	—1.1	—0.045	—1.1	—0.048	—1.2
10 a. m.	—0.024	—0.6	—0.027	—0.7	—0.033	—0.8	—0.040	—1.0	—0.040	—1.0	—0.042	—1.1
11 a. m.	—0.017	—0.4	—0.020	—0.5	—0.024	—0.6	—0.024	—0.6	—0.024	—0.6	—0.027	—0.7
Noon	—0.005	—0.1	—0.007	—0.2	—0.004	—0.1	—0.002	—0.1	—0.003	—0.1	—0.005	—0.1
1 p. m.	0.014	0.4	0.016	0.4	0.021	0.5	0.023	0.6	0.024	0.6	0.025	0.6
2 p. m.	0.029	0.7	0.033	0.8	0.040	1.0	0.044	1.1	0.044	1.1	0.047	1.2
3 p. m.	0.040	1.0	0.044	1.1	0.049	1.2	0.053	1.3	0.051	1.3	0.057	1.4
4 p. m.	0.044	1.1	0.047	1.2	0.047	1.2	0.048	1.2	0.047	1.2	0.052	1.3
5 p. m.	0.038	1.0	0.040	1.0	0.038	1.0	0.036	0.9	0.034	0.9	0.037	0.9
6 p. m.	0.024	0.6	0.026	0.7	0.022	0.6	0.023	0.6	0.021	0.5	0.022	0.6
7 p. m.	0.007	0.2	0.008	0.2	0.005	0.1	0.004	0.1	0.002	0.1	0.004	0.1
8 p. m.	—0.009	—0.2	—0.009	—0.2	—0.012	—0.3	—0.015	—0.4	—0.016	—0.4	—0.014	—0.4
9 p. m.	—0.023	—0.6	—0.026	—0.7	—0.028	—0.7	—0.029	—0.7	—0.027	—0.7	—0.025	—0.6
10 p. m.	—0.035	—0.9	—0.037	—0.9	—0.037	—0.9	—0.033	—0.8	—0.030	—0.8	—0.028	—0.7
11 p. m.	—0.035	—0.9	—0.036	—0.9	—0.033	—0.8	—0.030	—0.8	—0.027	—0.7	—0.024	—0.6
Midnight	—0.024	—0.6	—0.024	—0.6	—0.020	—0.5	—0.020	—0.5	—0.017	—0.4	—0.014	—0.4

TABLES OF CORRECTIONS TO P_1 AND P_2 FOR DAILY OSCILLATION—Continued.

II. HONGKONG.

[114° 12′ east of Greenwich; 22° 18′ north latitude.]

Hour.	January.		February.		March.		April.		May.		June.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m.	-0.007	-0.2	-0.010	-0.3	-0.010	-0.3	-0.003	-0.1	-0.003	-0.1	-0.003	-0.1
2 a. m.	-0.001	0.0	-0.001	0.0	0.003	0.1	0.012	0.3	0.009	0.2	0.007	0.2
3 a. m.	0.007	0.2	0.009	0.2	0.016	0.4	0.023	0.6	0.017	0.4	0.014	0.4
4 a. m.	0.011	0.3	0.014	0.4	0.020	0.5	0.025	0.6	0.016	0.4	0.015	0.4
5 a. m.	0.008	0.2	0.010	0.3	0.012	0.3	0.015	0.4	0.011	0.3	0.013	0.3
6 a. m.	-0.004	-0.1	-0.003	-0.1	-0.004	-0.1	0.000	0.0	-0.002	-0.1	-0.002	-0.1
7 a. m.	-0.019	-0.5	-0.020	-0.5	-0.022	-0.6	-0.018	-0.5	-0.019	-0.5	-0.011	-0.3
8 a. m.	-0.036	-0.9	-0.035	-0.9	-0.040	-1.0	-0.035	-0.9	-0.032	-0.8	-0.020	-0.5
9 a. m.	-0.053	-1.3	-0.048	-1.2	-0.052	-1.3	-0.045	-1.1	-0.041	-1.0	-0.027	-0.7
10 a. m.	-0.055	-1.4	-0.054	-1.4	-0.052	-1.3	-0.047	-1.2	-0.041	-1.0	-0.029	-0.7
11 a. m.	-0.039	-1.0	-0.043	-1.1	-0.043	-1.1	-0.039	-1.0	-0.036	-0.9	-0.024	-0.6
Noon.	-0.012	-0.3	-0.020	-0.5	-0.022	-0.6	-0.025	-0.6	-0.023	-0.6	-0.015	-0.4
1 p. m.	0.020	0.5	0.000	0.0	-0.005	-0.1	0.000	0.0	-0.004	-0.1	-0.002	-0.1
2 p. m.	0.041	1.0	0.035	0.9	0.031	0.8	0.022	0.6	0.015	0.4	0.013	0.3
3 p. m.	0.051	1.3	0.050	1.3	0.048	1.2	0.039	1.0	0.033	0.8	0.025	0.6
4 p. m.	0.048	1.2	0.051	1.3	0.054	1.4	0.047	1.2	0.044	1.1	0.036	0.9
5 p. m.	0.037	0.9	0.042	1.1	0.051	1.3	0.046	1.2	0.045	1.1	0.036	0.9
6 p. m.	0.026	0.7	0.032	0.8	0.040	1.0	0.036	0.9	0.037	0.9	0.029	0.7
7 p. m.	0.012	0.3	0.020	0.5	0.026	0.7	0.022	0.6	0.025	0.6	0.014	0.4
8 p. m.	-0.003	-0.1	0.005	0.1	0.008	0.2	0.005	0.1	0.007	0.2	-0.002	-0.1
9 p. m.	-0.009	-0.2	-0.007	-0.2	-0.009	-0.2	-0.012	-0.3	-0.006	-0.2	-0.013	-0.3
10 p. m.	-0.013	-0.3	-0.014	-0.4	-0.019	-0.5	-0.023	-0.6	-0.019	-0.5	-0.025	-0.6
11 p. m.	-0.012	-0.3	-0.015	-0.4	-0.019	-0.5	-0.023	-0.6	-0.020	-0.5	-0.024	-0.6
Midnight	-0.011	-0.3	-0.015	-0.4	-0.015	-0.4	-0.016	-0.4	-0.012	-0.3	-0.012	-0.3

Hour.	July.		August.		September.		October.		November.		December.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m.	-0.003	-0.1	-0.005	-0.1	-0.002	-0.1	-0.003	-0.1	-0.003	-0.1	-0.007	-0.2
2 a. m.	0.008	0.2	0.007	0.2	0.009	0.2	0.011	0.3	0.007	0.2	0.001	0.0
3 a. m.	0.014	0.4	0.015	0.4	0.017	0.4	0.019	0.5	0.016	0.4	0.009	0.2
4 a. m.	0.015	0.4	0.018	0.5	0.019	0.5	0.021	0.5	0.020	0.5	0.011	0.3
5 a. m.	0.011	0.3	0.015	0.4	0.013	0.3	0.012	0.3	0.017	0.4	0.007	0.2
6 a. m.	0.000	0.0	0.005	0.1	-0.001	0.0	-0.004	-0.1	0.001	0.0	-0.005	-0.1
7 a. m.	-0.012	-0.3	-0.008	-0.2	-0.015	-0.4	-0.021	-0.5	-0.016	-0.4	-0.022	-0.6
8 a. m.	-0.020	-0.5	-0.020	-0.5	-0.030	-0.8	-0.036	-0.9	-0.033	-0.8	-0.040	-1.0
9 a. m.	-0.027	-0.7	-0.028	-0.7	-0.038	-1.0	-0.047	-1.2	-0.048	-1.2	-0.054	-1.4
10 a. m.	-0.029	-0.7	-0.032	-0.8	-0.041	-1.0	-0.047	-1.2	-0.046	-1.2	-0.054	-1.4
11 a. m.	-0.026	-0.7	-0.028	-0.7	-0.033	-0.8	-0.033	-0.8	-0.030	-0.8	-0.038	-1.0
Noon.	-0.017	-0.4	-0.017	-0.4	-0.016	-0.4	-0.010	-0.3	-0.006	-0.2	-0.009	-0.2
1 p. m.	-0.015	-0.4	-0.001	0.0	0.005	0.1	0.015	0.4	0.024	0.6	0.023	0.6
2 p. m.	0.010	0.3	0.016	0.4	0.024	0.6	0.036	0.9	0.041	1.0	0.044	1.1
3 p. m.	0.022	0.6	0.030	0.8	0.038	1.0	0.046	1.2	0.048	1.2	0.054	1.4
4 p. m.	0.034	0.9	0.039	1.0	0.042	1.1	0.044	1.1	0.044	1.1	0.051	1.3
5 p. m.	0.038	1.0	0.041	1.0	0.040	1.0	0.035	0.9	0.034	0.9	0.040	1.0
6 p. m.	0.031	0.8	0.034	0.9	0.031	0.8	0.026	0.7	0.022	0.6	0.027	0.7
7 p. m.	0.018	0.5	0.018	0.5	0.017	0.4	0.009	0.2	0.005	0.1	0.012	0.3
8 p. m.	0.003	0.1	-0.001	0.0	-0.002	-0.1	-0.011	-0.3	-0.011	-0.3	-0.002	-0.1
9 p. m.	-0.012	-0.3	-0.019	-0.5	-0.018	-0.5	-0.021	-0.5	-0.018	-0.5	-0.011	-0.3
10 p. m.	-0.023	-0.6	-0.029	-0.7	-0.024	-0.6	-0.023	-0.6	-0.023	-0.6	-0.016	-0.4
11 p. m.	-0.024	-0.6	-0.027	-0.7	-0.022	-0.6	-0.020	-0.5	-0.021	-0.5	-0.014	-0.4
Midnight	-0.017	-0.4	-0.019	-0.5	-0.015	-0.4	-0.013	-0.3	-0.014	-0.4	-0.011	-0.3

TABLES OF CORRECTIONS TO P_1 AND P_2 FOR DAILY OSCILLATION—Continued.

III. ZI-KA-WEI.

[121° 26′ east of Greenwich; 31° 11′ north latitude.]

Hour.	January.		February.		March.		April.		May.		June.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m	—0.009	—0.2	—0.008	—0.2	—0.012	—0.3	—0.002	—0.1	—0.006	—0.2	—0.006	—0.2
2 a. m	—0.007	—0.2	—0.003	—0.1	—0.004	—0.1	0.007	0.2	0.003	0.1	0.002	0.1
3 a. m	0.000	0.0	0.006	0.2	0.009	0.2	0.017	0.4	0.009	0.2	0.005	0.1
4 a. m	0.007	0.2	0.011	0.3	0.015	0.4	0.020	0.5	0.011	0.3	0.010	0.3
5 a. m	0.007	0.2	0.011	0.3	0.011	0.3	0.016	0.4	0.008	0.2	0.007	0.2
6 a. m	—0.001	0.0	—0.002	0.1	0.003	0.1	0.003	0.1	—0.002	—0.1	—0.002	—0.1
7 a. m	—0.011	—0.3	—0.009	—0.2	—0.012	—0.3	—0.012	—0.3	—0.012	—0.3	—0.012	—0.3
8 a. m	—0.023	—0.6	—0.023	—0.6	—0.026	—0.7	—0.023	—0.6	—0.021	—0.5	—0.020	—0.5
9 a. m	—0.027	—0.7	—0.032	—0.8	—0.033	—0.8	—0.032	—0.8	—0.027	—0.7	—0.022	—0.6
10 a. m	—0.039	—1.0	—0.035	—0.9	—0.034	—0.9	—0.036	—0.9	—0.027	—0.7	—0.022	—0.6
11 a. m	—0.022	—0.6	—0.029	—0.7	—0.028	—0.7	—0.029	—0.7	—0.022	—0.6	—0.019	—0.5
Noon	0.007	0.2	—0.008	—0.2	—0.011	—0.3	—0.017	—0.4	—0.010	—0.3	—0.009	—0.2
1 p. m	0.032	0.8	0.017	0.4	0.010	0.3	0.001	0.0	0.005	0.1	0.004	0.1
2 p. m	0.041	1.0	0.033	0.8	0.028	0.7	0.016	0.4	0.017	0.4	0.013	0.3
3 p. m	0.041	1.0	0.036	0.9	0.036	0.9	0.030	0.8	0.027	0.7	0.021	0.5
4 p. m	0.032	0.8	0.032	0.8	0.038	1.0	0.035	0.9	0.032	0.8	0.029	0.7
5 p. m	0.023	0.6	0.024	0.6	0.033	0.8	0.032	0.8	0.033	0.8	0.032	0.8
6 p. m	0.012	0.3	0.012	0.3	0.023	0.6	0.024	0.6	0.025	0.6	0.026	0.7
7 p. m	0.003	0.1	0.005	0.1	0.014	0.4	0.014	0.4	0.015	0.4	0.013	0.3
8 p. m	—0.006	—0.2	—0.003	—0.1	0.000	0.0	—0.002	—0.1	0.001	0.0	0.000	0.0
9 p. m	—0.012	—0.3	—0.010	—0.3	—0.013	—0.3	—0.015	—0.4	—0.013	—0.3	—0.013	—0.3
10 p. m	—0.013	—0.3	—0.013	—0.3	—0.017	—0.4	—0.019	—0.5	—0.017	—0.4	—0.019	—0.5
11 p. m	—0.011	—0.3	—0.012	—0.3	—0.014	—0.4	—0.017	—0.4	—0.014	—0.4	—0.015	—0.4
Midnight	—0.012	—0.3	—0.009	—0.2	—0.018	—0.5	—0.012	—0.3	—0.015	—0.4	—0.015	—0.4

Hour.	July.		August.		September.		October.		November.		December.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m	—0.001	0.0	—0.002	—0.1	—0.002	—0.1	0.002	0.1	—0.003	—0.1	—0.006	—0.2
2 a. m	0.007	0.2	0.006	0.2	0.005	0.1	0.008	0.2	0.002	0.1	0.003	0.1
3 a. m	0.012	0.3	0.011	0.3	0.012	0.3	0.015	0.4	0.007	0.2	0.001	0.0
4 a. m	0.013	0.3	0.014	0.4	0.015	0.4	0.018	0.5	0.012	0.3	0.009	0.2
5 a. m	0.009	0.2	0.010	0.3	0.012	0.3	0.012	0.3	0.010	0.3	0.009	0.2
6 a. m	0.001	0.0	0.001	0.0	0.003	0.1	0.003	0.1	0.000	0.0	0.001	0.0
7 a. m	—0.010	—0.3	—0.011	—0.3	—0.009	—0.2	—0.012	—0.3	—0.014	—0.4	—0.010	—0.3
8 a. m	—0.017	—0.4	—0.019	—0.5	—0.019	—0.5	—0.029	—0.7	—0.030	—0.8	—0.023	—0.6
9 a. m	—0.021	—0.5	—0.025	—0.6	—0.027	—0.7	—0.034	—0.9	—0.038	—1.0	—0.036	—0.9
10 a. m	—0.021	—0.5	—0.026	—0.7	—0.028	—0.7	—0.030	—0.8	—0.037	—0.9	—0.038	—1.0
11 a. m	—0.016	—0.4	—0.019	—0.5	—0.020	—0.5	—0.020	—0.5	—0.024	—0.6	—0.023	—0.6
Noon	—0.009	—0.2	—0.008	—0.2	—0.007	—0.2	—0.001	0.0	0.000	0.0	0.004	0.1
1 p. m	0.001	0.0	0.003	0.1	0.008	0.2	0.021	0.5	0.022	0.6	0.028	0.7
2 p. m	0.011	0.3	0.015	0.4	0.020	0.5	0.029	0.7	0.030	0.8	0.038	1.0
3 p. m	0.019	0.5	0.024	0.6	0.025	0.6	0.030	0.8	0.032	0.8	0.038	1.0
4 p. m	0.025	0.6	0.026	0.7	0.023	0.6	0.027	0.7	0.026	0.7	0.030	0.8
5 p. m	0.028	0.7	0.029	0.7	0.019	0.5	0.021	0.5	0.018	0.5	0.021	0.5
6 p. m	0.022	0.6	0.024	0.6	0.013	0.3	0.012	0.3	0.005	0.1	0.009	0.2
7 p. m	0.013	0.3	0.015	0.4	0.004	0.1	0.001	0.0	—0.005	—0.1	—0.001	0.0
8 p. m	—0.001	0.0	0.000	0.0	—0.012	—0.3	—0.010	—0.3	—0.012	—0.3	—0.006	—0.2
9 p. m	—0.013	—0.3	—0.015	—0.4	—0.023	—0.6	—0.017	—0.4	—0.018	—0.5	—0.011	—0.3
10 p. m	—0.019	—0.5	—0.019	—0.5	—0.024	—0.6	—0.018	—0.5	—0.021	—0.5	—0.012	—0.3
11 p. m	—0.017	—0.4	—0.018	—0.5	—0.021	—0.5	—0.014	—0.4	—0.016	—0.4	—0.011	—0.3
Midnight	—0.009	—0.2	—0.009	—0.2	—0.010	—0.3	—0.003	—0.1	—0.007	—0.2	—0.010	—0.3

TABLES OF CORRECTIONS TO P_1 AND P_2 FOR DAILY OSCILLATION—Continued.

IV. TOKIO.

[139° 45′ east of Greenwich; 35° 41′ north latitude.]

Hour.	January.		February.		March.		April.		May.		June.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m	—0.007	—0.2	—0.003	—0.1	—0.010	—0.3	—0.005	—0.1	—0.003	—0.1	0.004	0.1
2 a. m	—0.009	—0.2	—0.002	—0.1	—0.003	—0.1	0.003	0.1	0.002	0.1	0.004	0.1
3 a. m	—0.002	—0.1	0.004	0.1	0.004	0.1	0.005	0.1	0.002	0.1	0.004	0.1
4 a. m	0.002	0.1	0.004	0.1	0.001	0.0	0.004	0.1	0.001	0.0	0.000	0.0
5 a. m	0.000	0.0	—0.003	—0.1	—0.007	—0.2	—0.004	—0.1	—0.009	—0.2	—0.009	—0.2
6 a. m	—0.009	—0.2	—0.011	—0.3	—0.017	—0.4	—0.017	—0.4	—0.019	—0.5	—0.017	—0.4
7 a. m	—0.019	—0.5	—0.026	—0.7	—0.028	—0.7	—0.026	—0.7	—0.025	—0.6	—0.025	—0.6
8 a. m	—0.029	—0.7	—0.034	—0.9	—0.035	—0.9	—0.028	—0.7	—0.028	—0.7	—0.028	—0.7
9 a. m	—0.036	—0.9	—0.035	—0.9	—0.037	—0.9	—0.029	—0.7	—0.025	—0.6	—0.025	—0.6
10 a. m	—0.030	—0.8	—0.030	—0.8	—0.029	—0.7	—0.025	—0.6	—0.022	—0.6	—0.022	—0.6
11 a. m	—0.006	—0.2	—0.016	—0.4	—0.016	—0.4	—0.012	—0.3	—0.013	—0.3	—0.015	—0.4
Noon	0.023	0.6	0.009	0.2	0.002	0.1	0.006	0.2	0.002	0.1	—0.003	—0.1
1 p. m	0.043	1.1	0.033	0.8	0.026	0.7	0.021	0.5	0.015	0.4	0.009	0.2
2 p. m	0.045	1.1	0.043	1.1	0.039	1.0	0.034	0.9	0.027	0.7	0.019	0.5
3 p. m	0.041	1.0	0.042	1.1	0.042	1.1	0.043	1.1	0.034	0.9	0.025	0.6
4 p. m	0.032	0.8	0.038	1.0	0.042	1.1	0.041	1.0	0.036	0.9	0.031	0.8
5 p. m	0.019	0.5	0.025	0.6	0.033	0.8	0.036	0.9	0.035	0.9	0.034	0.9
6 p. m	0.005	0.1	0.012	0.3	0.020	0.5	0.024	0.6	0.027	0.7	0.024	0.6
7 p. m	—0.005	—0.1	0.001	0.0	0.009	0.2	0.009	0.2	0.014	0.4	0.014	0.4
8 p. m	—0.011	—0.3	—0.007	—0.2	—0.004	—0.1	—0.010	—0.3	0.001	0.0	0.002	0.1
9 p. m	—0.014	—0.4	—0.011	—0.3	—0.012	—0.3	—0.017	—0.4	—0.009	—0.2	—0.011	—0.3
10 p. m	—0.014	—0.4	—0.011	—0.3	—0.014	—0.4	—0.018	—0.5	—0.011	—0.3	—0.014	—0.4
11 p. m	—0.012	—0.3	—0.009	—0.2	—0.011	—0.3	—0.017	—0.4	—0.008	—0.2	—0.011	—0.3
Midnight	—0.007	—0.2	—0.007	—0.2	—0.007	—0.2	—0.014	—0.4	—0.002	—0.1	—0.004	—0.1

Hour.	July.		August.		September.		October.		November.		December.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m	—0.002	—0.1	—0.001	0.0	0.001	0.0	0.002	0.1	0.000	0.0	0.001	0.0
2 a. m	0.003	0.1	0.003	0.1	0.005	0.1	0.006	0.2	0.001	0.0	0.000	0.0
3 a. m	0.003	0.1	0.005	0.1	0.009	0.2	0.009	0.2	0.005	0.1	0.003	0.1
4 a. m	—0.001	0.0	0.003	0.1	0.009	0.2	0.005	0.1	0.002	0.1	0.006	0.2
5 a. m	—0.009	—0.2	—0.006	—0.1	0.003	0.1	—0.002	—0.1	—0.004	—0.1	0.001	0.0
6 a. m	—0.014	—0.4	—0.013	—0.3	—0.005	—0.1	—0.011	—0.3	—0.014	—0.4	—0.012	—0.3
7 a. m	—0.019	—0.5	—0.019	—0.5	—0.014	—0.4	—0.022	—0.6	—0.028	—0.7	—0.022	—0.6
8 a. m	—0.019	—0.5	—0.021	—0.5	—0.018	—0.5	—0.031	—0.8	—0.037	—0.9	—0.033	—0.8
9 a. m	—0.017	—0.4	—0.023	—0.6	—0.022	—0.6	—0.030	—0.8	—0.037	—0.9	—0.042	—1.1
10 a. m	—0.014	—0.4	—0.019	—0.5	—0.020	—0.5	—0.022	—0.6	—0.031	—0.8	—0.036	—0.9
11 a. m	—0.008	—0.2	—0.009	—0.2	—0.009	—0.2	—0.010	—0.3	—0.011	—0.3	—0.019	—0.3
Noon	0.002	0.1	0.003	0.1	0.004	0.1	0.013	0.3	0.015	0.4	0.016	0.4
1 p. m	0.011	0.3	0.014	0.4	0.016	0.4	0.031	0.8	0.032	0.8	0.035	0.9
2 p. m	0.020	0.5	0.024	0.6	0.026	0.7	0.039	1.0	0.037	0.9	0.040	1.0
3 p. m	0.026	0.7	0.031	0.8	0.028	0.7	0.039	1.0	0.035	0.9	0.036	0.9
4 p. m	0.029	0.7	0.031	0.8	0.026	0.7	0.033	0.8	0.031	0.8	0.026	0.7
5 p. m	0.027	0.7	0.028	0.7	0.019	0.5	0.023	0.6	0.021	0.5	0.016	0.4
6 p. m	0.018	0.5	0.020	0.5	0.013	0.3	0.011	0.3	0.010	0.3	0.005	0.1
7 p. m	0.008	0.2	0.007	0.2	—0.002	—0.1	0.001	0.0	0.001	0.0	—0.004	—0.1
8 p. m	—0.003	—0.1	—0.009	—0.2	—0.014	—0.4	—0.006	—0.2	—0.005	—0.1	—0.010	—0.3
9 p. m	—0.013	—0.3	—0.015	—0.4	—0.016	—0.4	—0.011	—0.3	—0.008	—0.2	—0.012	—0.3
10 p. m	—0.015	—0.4	—0.016	—0.4	—0.015	—0.4	—0.010	—0.3	—0.007	—0.2	—0.010	—0.3
11 p. m	—0.014	—0.4	—0.014	—0.4	—0.012	—0.3	—0.006	—0.2	—0.006	—0.2	—0.007	—0.2
Midnight	—0.009	—0.2	—0.008	—0.2	—0.007	—0.2	—0.003	—0.1	—0.003	—0.1	—0.001	0.0

TABLES OF CORRECTIONS TO P_1 AND P_2 FOR DAILY OSCILLATION—Continued.

V. NEMURO.

[145° 35′ east of Greenwich; 45° 20′ north latitude.]

Hour.	January.		February.		March.		April.		May.		June.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m	—0.003	—0.1	0.000	0.0	—0.006	—0.2	—0.001	0.0	—0.008	—0.2	0.004	0.1
2 a. m	—0.005	—0.1	0.002	0.1	0.002	0.1	0.001	0.0	—0.004	—0.1	0.008	0.2
3 a. m	0.001	0.0	0.006	0.2	0.005	0.1	0.003	0.1	—0.001	0.0	0.008	0.2
4 a. m	0.005	0.1	0.005	0.1	0.004	0.1	0.002	0.1	—0.004	—0.1	0.004	0.1
5 a. m	0.003	0.1	0.004	0.1	0.001	0.0	—0.004	—0.1	—0.007	—0.2	—0.001	0.0
6 a. m	—0.001	0.0	0.000	0.0	—0.004	—0.1	—0.011	—0.3	—0.010	—0.3	—0.004	—0.1
7 a. m	—0.011	—0.3	—0.008	—0.2	—0.009	—0.2	—0.013	—0.3	—0.010	—0.3	—0.008	—0.2
8 a. m	—0.017	—0.4	—0.012	—0.3	—0.011	—0.3	—0.011	—0.3	—0.006	—0.2	—0.007	—0.2
9 a. m	—0.019	—0.5	—0.014	—0.4	—0.011	—0.3	—0.014	—0.4	—0.004	—0.1	—0.006	—0.2
10 a. m	—0.014	—0.4	—0.013	—0.3	—0.008	—0.2	—0.006	—0.2	—0.002	—0.1	—0.005	—0.1
11 a. m	0.005	0.1	—0.004	—0.1	0.000	0.0	0.001	0.0	0.005	0.1	0.000	0.0
Noon	0.019	0.5	0.011	0.3	0.011	0.3	0.011	0.3	0.012	0.3	0.006	0.2
1 p. m	0.024	0.6	0.021	0.5	0.022	0.6	0.018	0.5	0.017	0.4	0.010	0.3
2 p. m	0.021	0.5	0.022	0.6	0.024	0.6	0.025	0.6	0.023	0.6	0.012	0.3
3 p. m	0.013	0.3	0.017	0.4	0.020	0.5	0.027	0.7	0.024	0.6	0.013	0.3
4 p. m	0.008	0.2	0.011	0.3	0.015	0.4	0.023	0.6	0.020	0.5	0.013	0.3
5 p. m	0.003	0.1	0.003	0.1	0.008	0.2	0.016	0.4	0.017	0.4	0.009	0.2
6 p. m	—0.004	—0.1	—0.005	—0.1	—0.001	0.0	0.008	0.2	0.008	0.2	0.002	0.1
7 p. m	—0.005	—0.1	—0.009	—0.2	—0.009	—0.2	—0.006	—0.2	—0.001	0.0	—0.005	—0.1
8 p. m	—0.008	—0.2	—0.012	—0.3	—0.014	—0.4	—0.017	—0.4	—0.013	—0.3	—0.014	—0.4
9 p. m	—0.007	—0.2	—0.012	—0.3	—0.016	—0.4	—0.017	—0.4	—0.015	—0.4	—0.016	—0.4
10 p. m	—0.006	—0.2	—0.011	—0.3	—0.017	—0.4	—0.017	—0.4	—0.016	—0.4	—0.015	—0.4
11 p. m	—0.001	0.0	—0.007	—0.2	—0.012	—0.3	—0.014	—0.4	—0.014	—0.4	—0.010	—0.3
Midnight	0.003	0.1	—0.001	0.0	—0.009	—0.2	—0.009	—0.2	—0.008	—0.2	—0.005	—0.1

Hour.	July.		August.		September.		October.		November.		December.	
	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.	Inches.	Millimeters.
1 a. m	0.004	0.1	0.004	0.1	0.002	0.1	0.000	0.0	—0.003	—0.1	—0.002	—0.1
2 a. m	0.007	0.2	0.008	0.2	0.004	0.1	0.004	0.1	0.000	0.0	—0.004	—0.1
3 a. m	0.008	0.2	0.010	0.3	0.003	0.1	0.003	0.1	0.003	0.1	0.002	0.1
4 a. m	0.002	0.1	0.007	0.2	—0.001	0.0	—0.002	—0.1	0.002	0.1	0.003	0.1
5 a. m	—0.002	—0.1	—0.001	0.0	—0.005	—0.1	—0.004	—0.1	0.002	0.1	0.002	0.1
6 a. m	—0.006	—0.2	—0.004	—0.1	—0.013	—0.3	—0.010	—0.3	—0.004	—0.1	—0.004	—0.1
7 a. m	—0.008	—0.2	—0.007	—0.2	—0.013	—0.3	—0.017	—0.4	—0.014	—0.4	—0.009	—0.2
8 a. m	—0.008	—0.2	—0.008	—0.2	—0.015	—0.4	—0.018	—0.5	—0.017	—0.4	—0.015	—0.4
9 a. m	—0.008	—0.2	—0.009	—0.2	—0.018	—0.5	—0.017	—0.4	—0.016	—0.4	—0.018	—0.5
10 a. m	—0.007	—0.2	—0.006	—0.2	—0.012	—0.3	—0.012	—0.3	—0.011	—0.3	—0.011	—0.3
11 a. m	—0.002	—0.1	—0.002	—0.1	—0.004	—0.1	—0.003	—0.1	0.005	0.1	0.009	0.2
Noon	0.003	0.1	0.003	0.1	0.005	0.1	0.013	0.3	0.023	0.6	0.025	0.6
1 p. m	0.007	0.2	0.009	0.2	0.011	0.3	0.023	0.6	0.025	0.6	0.030	0.8
2 p. m	0.011	0.3	0.015	0.4	0.018	0.5	0.022	0.6	0.023	0.6	0.027	0.7
3 p. m	0.012	0.3	0.015	0.4	0.018	0.5	0.018	0.5	0.015	0.4	0.018	0.5
4 p. m	0.013	0.3	0.012	0.3	0.016	0.4	0.016	0.4	0.009	0.2	0.012	0.3
5 p. m	0.011	0.3	0.011	0.3	0.011	0.3	0.010	0.3	0.002	0.1	0.003	0.1
6 p. m	0.004	0.1	0.005	0.1	0.008	0.2	0.002	0.1	—0.003	—0.1	—0.005	—0.1
7 p. m	—0.002	—0.1	—0.006	—0.2	—0.003	—0.1	—0.001	0.0	—0.006	—0.2	—0.009	—0.2
8 p. m	—0.012	—0.3	—0.013	—0.3	—0.008	—0.2	—0.006	—0.2	—0.009	—0.2	—0.012	—0.3
9 p. m	—0.013	—0.3	—0.013	—0.3	—0.009	—0.2	—0.010	—0.3	—0.010	—0.3	—0.014	—0.4
10 p. m	—0.012	—0.3	—0.013	—0.3	—0.008	—0.2	—0.010	—0.3	—0.008	—0.2	—0.015	—0.4
11 p. m	—0.006	—0.2	—0.009	—0.2	—0.005	—0.1	—0.005	—0.1	—0.004	—0.1	—0.014	—0.3
Midnight	0.000	0.0	—0.004	—0.1	0.000	0.0	—0.004	—0.1	0.001	0.0	—0.008	—0.2

Limitation of the use of the barocyclonometer.—The direction of the cyclone's movement determined by means of the barocyclonometer, as described, has all the reliability which can be secured without telegraphic dispatches from places over which the center is passing in succession, *provided the place of observation has been stationary during the interval between the two observations,* as, for instance, a station on land or a ship at anchor. But what about the chief use of the instrument—that is, on board of ships under way? We are far from claiming for the barocyclonometer a usefulness which it does not possess. We do not recommend its use for determining the direction in which the storm is moving by means of the "third approximation" as long as the ship, steaming on her course, finds herself in zone A. The vessel's speed may be considerable compared with that of the storm's advance, and it might easily happen that, owing to the course of the ship and the distance covered, the small needle pointed in a seemingly entirely wrong direction—as each one may easily ascertain for himself by means of a few pencil lines. But with the vortex at such a distance as the ship's position in zone A implies it suffices to know the direction in which the center lies, the approximate distance of the center and, in a general way, whether the combined effect of its movement and the ship's course and speed brings the observer nearer to the vortex or not. The two latter points can be learned from the indications and behavior of the barometer; the former, with great reliability, from the wind disk. From both together a fairly good estimate can be formed of the direction of the trajectory.

The case is, however, different in zone B, and especially in zone C. There the ship will rarely make much headway while the rapid veering of the wind will allow of making the third approximation at short intervals, so that the place of observation will be but little displaced during the interval, although some allowance should always be made for the ship's course and run.

When applying the barocyclonometer for the purpose for which it has been designed the observer must bear in mind the sound advice concerning the use of this instrument given by Fr. Froc, S. J., in his memoir on the "De Witte Typhoon" of August 1–6, 1901:

To finish, we will answer a question which has been put to us by several officers, who, at anchor during the typhoon, took advantage of its approach to study the indications of the barocyclonometer, an instrument of somewhat recent use, constructed and perfected by Rev. Father José Algué, Director of the Manila Observatory. This instrument is really very valuable, and may be of most signal service at sea if handled by a practiced observer and read with an experienced eye. One must, however, never forget that like any other apparatus constructed for general requirements, the indications it gives are based upon means, that consequently they may not, in exceptional cases, be taken literally and rigorously, but need, in such circumstances, to be fitted to particular wants. Thus used, the instrument gives useful information, but it would be excessive there to seek a guide for particulars in the study of exceptional cases.

We shall therefore say of it what must be said of all the most perfect instruments of navigation: It is well worth recommending to captains, but neither this nor any other instrument will dispense the commander of a ship to appeal to his experience. This is the most valuable of all instruments, which must never be locked up, particularly when it has been acquired, increased, and enriched by ten, fifteen, twenty years and more of sailing in the same parts, and of conscientious, diligent observation. For a captain thus qualified, certain small signs, insignificant for anyone else, and which it would even be difficult to explain in a general treatise, may give more reliable warnings of the danger than all those that are met with in the best books. Thus the barocyclonometer is a great progress, but it requires commentaries and explanations. We will here only mention one point on which some seamen may have been led astray, namely, the direction of the wind in certain parts on the approach of cyclones, and, to speak of the regions best known to us, we shall limit ourselves to the mouth of the Yangtze-Kiang between the group of the Chusan Islands and the old bed of the Hoangho.

It is almost a rule that, each time a typhoon approaches, particularly when it comes to strike the coast to the south of Ningpo, the bearing of the wind grievously leads in error those who witness the phenomenon for the first time. Keeping to the study of the typhoon of August 3, let us take the report of Zi-ka-wei, printed in the appendix, or that of the North Saddle Island light-house, which is situated farther off. We shall find, at the Observatory, winds (and we may add clouds) coming from the east, and at the light-house continual breezes from east-southeast, force 6, 7, and even 8—that is, typhoon winds—during the whole day, on the 2d, on the 3d, not only when the typhoon landed on the coast, almost right to the south, but at the time when it was clearly in the south-southeast and southeast between Formosa and Nafa.

The explanation which we give without development is twofold. In the first place, the apparent anomaly results from the shape of the isobars, which, far from keeping to the circular or even elliptical shape, assume along the coast undulated, tortuous, and apparently most capricious contours, though all submitted to laws which will some day be formulated.

The second cause of the deviation of the wind, which is not without influence upon the deformation of the isobars, is the call of air taking place generally in summer from the sea toward the overheated plains situated on the continent to the northwest and to the north of Shanghai (Western China, Mongolia, and Chili). The air put in motion by the typhoon ought to incline to northeast or at most to east-northeast. On the other hand, on getting near the coasts it finds a slope and a certain attraction which ought to make it flow from south-southeast or from southeast. As long as the typhoon's vigor has not entered into the period of violence, close to the center, the air, subject to two forces at an angle between them, follows the resultant and seems to diverge, while at other times of the year—in October, for instance—the air will rush straight in the direction of the center of a distant typhoon.

We would advise those who could find the leisure to study Father Algué's instrument, reading again in quiet, far from the turmoil of the storm, the report of Capt. Geo. Payne, of the steamship *Laisang*, who bore the brunt of the cyclone in open sea. We are confident that this study will be fruitful and lead to satisfactory results.

Practical application of the barocyclonometer.—In order to illustrate the application of the preceding rules we give a few instances taken from actual observations. The calculations are made without corrections for oscillation except in cases in which the difference of the two values of D_2 exceeds five units. In every instance, however, the value y, resulting from calculation with corrections applied, is given in brackets.

(1) (*a*) During the typhoon of October 12 and 13, 1897, the famous "Typhoon of Samar and Leyte,"[1] the observations at Capiz, on the Island of Panay, were as follows:

October 12, 7.30 p.m.: Barometer 739.0 millimeters; wind, W.
October 12, 8.05 p.m.: Barometer 738.0 millimeters; wind, SW. } Zone D.

Capiz is within zone 11°—17°, October in Group II; hence, P=755. Hence we have, according to formula,

$$\frac{755-738}{755-739}=\frac{100}{x} \therefore x=94 \qquad [y=94]$$

The resulting positions of the needles are given on Plate XLI; and from that follows a direction of the track toward west by north.

(*b*) During the same typhoon the observations at Manila were:

October 13, 6 a. m.: Barometer, 752.38; wind, NE.
October 13, 11 a. m.: Barometer, 753.25; wind, E. } Zone A.

Hence,

$$\frac{755-753.25}{755-752.38}=\frac{100}{x} \therefore x=149 \qquad [y=145]$$

Plate XLI shows the positions of the needles; the direction of the track is west-northwest by north.

(2) During the typhoon of September 16–17, 1894, the observations at Manila (P=755) on the 16th were:

September 16, 1 p.m.: Barometer, 749.84; lowest clouds, WNW.
September 16, 6 p.m.: Barometer, 746.85; lowest clouds, W. } Zone B–C.

According to formula,

$$\frac{755-746.85}{755-749.84}=\frac{100}{x} \therefore x=63 \qquad [y=64]$$

Plate XLII shows the disposition of the different needles; direction of motion of the center, west by north.

(3) During the "Gravina Typhoon" of May 13, 1895,[2] at San Isidro, Province of Nueva Ecija, the observations were as follows:

May 13, 10.00 a.m.: Barometer, 749.76; wind, SE.
May 13, 10.30 a.m.: Barometer, 748.00; wind, S. } Zone B.

The formula reads:

$$\frac{755-748.00}{755-749.76}=\frac{100}{x} \therefore x=75 \qquad [y=80]$$

The direction of the track as shown by Plate XLII was northeast by north.

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[1] See "El Baguio de Samar y Leyte," Manila, 1898.
[2] "Baguio de Gravina," Manila, 1895.

(4) During the terrific storm of September 7, 1902, which caused so much damage in certain parts of Japan, the observations made on board the U. S. A. T. *Sumner* could have been made good use of to find the track of the typhoon by means of the barocyclonometer.

OBSERVATIONS MADE ON BOARD THE U. S. A. T. SUMNER.

[From San Francisco to Manila.]

Date.		Position.		Barometer.	Wind.		Remarks.
Day.	Hour.	Latitude (north).	Longitude (east).		Direction.	Force, 0-12.	
		° ′	° ′	*Inches.*			
Sept. 5	6.45 a. m	34 18	138 13	29.65	ESE.	2	SSE.; swell; squally.
	10.51 a. m	34 08			ESE.	2	Do.
	2.54 p. m	33 46	136 40	.54			Do.
	8 p. m	33 42		.54	SSE.	5	Mountainous sea from SSE.; squally; exceptionally heavy sea. Expecting we are either overtaking a typhoon coming across the China Sea or are already near its outer edge; put the engine under slow bell and heave the ship to, awaiting results. Very heavy sea running, hard wind and rain squalls of short duration, wind hauling to NE. about 9.30 p. m.
Sept. 6	6.59 a. m	33 02	135 71	.52	NE.	10	Barometer falling $\frac{4}{100}$ of an inch per hour; sea from NE.
	8 p. m	32 30	133 23	.42	NE.	7	Terrible, mountainous sea from NE.
Sept. 7	12.30 a. m	31 57	132 46				Wind and sea increasing; barometer dropping rapidly.
	7 a. m			28.22	N. by E.	12	The center of the storm can not be very far distant.
	11 a. m	31 44	133 44	.17	E. by N.	12	
	3.04 p. m			.12	E. by N.	12	The storm raged with unabated fury; terrible sea running and ship rolling something fearful until 4.30 p.m.; the wind suddenly shifting to SSE. and barometer commenced rising slowly.
	4.03 p. m	32 05	133 25	.09	E. by N.	12	
	8 p. m	31 54	133 10	.82	S.	10	Mountainous sea from NE.; the wind throughout the worst part of the gale coming from about E. by N. true and the sea being NNE.
Sept. 8	8 p. m	31 13	131 17	29.64	Variable.	2	First part of day heavy sea; sea from E. by N.-NNE.

We find that on September 6 at 8 p. m. the barometer reading was 29.42 inches and the wind was blowing strongly from the northeast. The barometer shows that the ship was then in zone B. At 7 a. m. of the 7th the barometer had fallen to 28.22 inches, corresponding to zone C, and the wind came from north by east. The use of the barocyclonometer would have been as follows:

Before commencing operations the observer would have set the central arrow of the wind disk in the direction of the mean trajectory of typhoons for the ship's place (32° 30′ north latitude and 133° 23′ east longitude) during September. The large chart shows this to be southwest-northeast. Having set the central arrow in this direction, he would have determined the ship's position relative to the vortex at 8 p. m. of the 6th, using the single end of the "double needle." The wind was from the northeast, the barometer reading indicated that he was in zone B. He would have moved the double needle until its single end passed through the tail end of that arrow in zone B, which was most nearly parallel to the direction of the wind—that is, northeast-southwest—then the other, double, end of the needle would have shown that the vortex lay south by east of the ship. After the observation at 7 a. m. of the next morning he would have determined the new position of the vortex by means of the plain end of the "graduated needle," without disturbing the rest of the arrangement. The barometer now showed that the ship was in zone C, the wind came from north by east. There is no arrow in zone C of the wind disk, which (with the arrangement described, see plate) is parallel to the north by east and south by west line. But Plate XLIII, which represents the present case, shows that the position of this arrow is between northwest and north-northwest—about 4° west of the latter point. By making the plain end of the second needle pass through the interpolated point the observer would have found that he had then the vortex to the south-southeast. For the use of Fournier's rule the two observations furnished the following data:

September 6, 8 p.m.: Barometer, 29.42 inches; wind, NE.
September 7, 7 a.m.: Barometer, 28.22 inches; wind, N. by E.

The ship being between 25° — 32° (at least on the 7th), and September belonging to Group III, the value of P was 29.65 inches.

Hence,

$$\frac{29.65-28.22}{29.65-29.42}=\frac{100}{x} \therefore x=19 \qquad [y=20]$$

With disposition of the apparatus as described, the small needle pointing to 19 on the graduation of the graduated needle would have shown the track of the cyclone to be south by west to north by east. However, the course of the ship during the interval between the two observations, which was south by east, would have had to be taken into consideration. On account of this course the instrument would have shown a less inclination of the track to the northeast than it actually had. The composed direction was north-northeast. (See Pl. XL.)

The vortex was, therefore, recurving to the west of the ship, as was shown in the Weather Bulletin for September, 1902, issued by the Philippine Weather Bureau.

(5) (*a*) At noon July 26, 1902, the barometer on board the steamship *Loonsang* was 29.33 inches, and the wind blew from west by north; she was in zone C. At 3 p. m. the barometer had fallen to 29.22 inches, and the wind had backed to southwest. By Fournier's rule we have:

$$\frac{29.73-29.22}{29.73-29.33}=\frac{100}{x} \therefore x=78.$$

The position of the needles would have been as shown on Plate XLIII, the resulting direction being east by south—west by north.

The calculation with readings corrected for daily oscillation gives a somewhat different result. Since the ship was below the twenty-first degree of north latitude, we take the corrections from the Manila table:

July 26, noon, 29.33 — 0.02 inches = 29.31 inches.
July 26, 3 p.m., 29.22 + 0.02 inches = 29.24 inches.

Hence,

$$\frac{29.73-29.24}{29.73-29.31}=\frac{100}{y} \therefore y=86$$

The direction corresponding to this value of D_2 is shown on the plate by means of a dotted line.

(*b*) On the same day, July 26, at 3 p. m. the barometer of the steamship *Rosetta Maru* stood at 29.22 inches, and the wind came from north-northwest. At 6 p. m. the barometer indicated 29.12 inches, with the wind blowing from northeast.

Fournier's formula gives,

$$\frac{29.73-29.12}{29.73-29.22}=\frac{100}{x} \therefore x=84 \qquad [y=80]$$

The track resulted, therefore, as shown by the small needle on Plate XLIV, east-northeast by north to west-southwest by south. But owing to the ship's course being almost opposite to the motion of the vortex (see Pl. XL), the composition of the two motions will give the true direction of the track, which in the present case will be east by south to west by north, as was the case with the *Loonsang*.

(*c*) On the 27th at 3 a. m. the barometer reading on the *Rosetta Maru* was 28.85 inches with wind coming from southeast. Comparing this observation with the one made at 6 p. m. on the preceding day, we find by Fournier's rule:

$$\frac{29.73-28.85}{29.73-29.12}=\frac{100}{x} \therefore x=69 \qquad [y=70]$$

The small needle will point to northwest, and, composing this with the ship's course, we find that the average direction of the center from 6 p. m. of the 26th till 3 a. m. of 27th was northwest by west. (See Pl. XLIV.)

(6) Another typhoon which was felt so severely in Hongkong in the beginning of August, 1902, crossed to the north of Aparri on the evening of July 31. The trajectory found by means of the barocyclonometer was east by south to west by north. Aparri was successively in zones A and B from July 31 to August 1, and the following observations were made:

July 31, 10 p. m.: Barometer, 751.1 millimeters; wind, NW.
August 1, 6 a. m.: Barometer, 746.4 millimeters; wind, WSW. } Zone B.

Whence we have,

$$\frac{755-746.4}{755-751.1}=\frac{100}{x} \therefore x=45.$$

Applying the corrections for daily oscillation we obtain the following:

July 31, 10 p. m.: 751.1 — 0.9 = 750.2 millimeters
August 1, 6 a. m.: 746.4 — 0.0 = 746.4 millimeters }, which gives $y=55$.

The two resulting directions are shown on Plate XLV.

(7) Observations made on board the German cruiser *Hertha* furnish some very interesting instances concerning the use of the barocyclonometer. From observations made at Nagasaki (see No. 8) we learn that that harbor was within zone A of a typhoon (passing afterwards close by to the south) on the morning of August 8, 1902. Hence the *Hertha*, which had left Nagasaki at 3.25 p. m. of the 7th, and was some hundred miles to the southeast by south of the port at noon of the 8th, found herself far within zone A. In fact at 8 p. m. of the 8th the barometer showed 751.79 millimeters—that is, between zones A and B—and at midnight it had fallen to 748.87 millimeters. By that time the ship had entered zone B. By taking the readings and wind-directions we can find the bearing of the center of the typhoon at the corresponding hours.

OBSERVATIONS MADE ON BOARD THE GERMAN CRUISER HERTHA.

No.	Date.		Barometer.	Wind.	Zone.	Fournier's formula.		Track of center to—	Approximate distance of center.
	Day.	Hour.				Uncorrected readings.	Corrected readings.		
			Mm.						*Miles.*
1	Aug. 8	Midnight.	748.87	ESE.	B.	------	------	------------	138
2	Aug. 9	2.00 a.m.	745.61	ESE.	C.	------	------	------------	118
3	----do ----	5.30 a.m.	743.01	SE. by E.	C.	74	73	NE.	79
4	----do ----	7.30 a.m.	740.58	E.	C.	80	78	NE. by E.	55
5	----do ----	8.30 a.m.	739.85	ESE.	C.	94	93	NE. by E.	42
6	----do ----	10.00 a.m.	730.99	SE. by E.	D.	60	60	NE. by E.	21
7	----do ----	11.45 am.	712.37	SE.	D.	54	55	NE. by E.	8

Observations 1 and 2 can not be combined for a determination of the direction of the trajectory since the wind had not changed during the interval.

The combination of readings 2 and 3 furnishes a remarkable instance of the influence of the ship's course upon the trajectory as found by means of the instrument. The small needle pointing to 74 gives the direction south by west and north by east, the course of the ship being almost southeast at that time. The actual bearing of the center, therefore, ought to have been, during the interval of the two readings, from about southwest to northeast. The position of the needles is shown on Plate XLV. Another instance is found by combining readings 6 and 7.

8. During the same typhoon which gave such a rough shaking to the *Hertha* another man-of-war, the French cruiser *Friant*, was at anchor in the harbor of Nagasaki. The following table exhibits the observations made on board and the results derived therefrom:

OBSERVATIONS MADE ON BOARD THE FRENCH CRUISER FRIANT.

No.	Date.		Barometer.	Wind.	Zone.	Fournier's formula.		Track of center to—	Approximate distance of center.
	Day.	Hour.				Uncorrected readings.	Corrected readings.		
			Mm.						*Miles.*
1	Aug. 9	8.00 a.m.	752.9	NE.	A.				
2	do	Noon.	751.9	ENE.	A.	52	70	NE. by E.	300
3	do	Midnight.	748.3	E.	B.	37	39	NE. by E.	200
4	Aug. 10	4.00 a.m.	745.4	ESE.	C.	66	72	NE. by E.	120
5	do	8.00 a.m.	740.2	ENE.	C.	62	57	NE. by E.	90
6	do	Noon.	729.3	NNE.	D.	56	57	NE. by E.	50
7	do	2.00 p.m.	728.8	N. by W.	D.	98	100	NE. by E.	25
8	do	4.00 p.m.	736.0	NW.	D.	139	143	NE. by E.	

Fournier's rule has been applied by combining observations 1 and 2, 2 and 3, and so on. The direction of the trajectory thus found coincides with Track VI on Plate XL.

Important caution.—Before applying the barocyclonometer it is of the greatest importance to ascertain whether the aneroid of the apparatus as installed in the chart room or the captain's cabin shows the pressure corresponding to its elevation above sea level or to the sea level itself. It should be corrected to show the latter.

Table of comparison.—To close this treatise we present the comparative table spoken of on page 15. The same needs no further explanation.

Zone.	Place of observation.	D_2 from uncorrected readings.	D_2 from corrected readings.	D_2-D_2.	Correction to P_1.	Correction to P_2.	Fall of barometer during interval, corrected for oscillation.
					Mm.	*Mm.*	
A.	Manila	149	145	+ 4	— 0.1	— 0.6	—[1] 0.82
A.	Nagasaki (Friant)	52	70	—18	— 0.5	— 0.2	0.7
B.	San Isidro	75	80	— 5	— 1.0	— 0.8	1.56
B.	Aparri	45	55	—10	— 0.9	0.0	3.8
B.	Nagasaki (Friant)	37	39	— 2	— 0.2	— 0.2	3.6
B–C.	Manila	63	64	— 1	+ 0.6	+ 0.6	2.99
C.	U. S. A. T. Sumner	19	20	— 1	0.0	— 0.3	[2] 30.70
C.	Steamship Loonsang	78	86	— 8	— 0.5	+ 0.5	[3] 1.8
C.	Cruiser Hertha	74	73	+ 1	+ 0.20	+ 0.15	2.65
C.	do	80	78	+ 2	+ 0.15	— 0.15	2.73
C.	do	94	93	+ 1	— 0.15	— 0.40	0.98
C.	Nagasaki (Friant)	66	72	— 6	— 0.2	+ 0.4	2.3
C.	do	62	57	+ 5	+ 0.4	— 0.5	6.1
D.	Capiz	94	94	0	— 0.7	— 0.9	1.02
D.	Steamship Rosetta Maru	84	80	+ 4	+ 1.0	+ 0.5	[4] 3.05
D.	do	69	70	— 1	+ 0.5	+ 1.0	[5] 6.35
D.	Cruiser Hertha	60	60	0	— 0.40	— 0.70	9.16
D.	do	54	55	— 1	— 0.70	— 0.53	18.45
D.	Nagasaki (Friant)	56	57	— 1	— 0.5	— 0.2	10.6
D.	do	98	100	— 2	— 0.2	+ 0.4	— 0.1
D.	do	139	143	— 4	+ 0.4	+ 0.7	— 7.5

[1] Barometer rose.
[2] Fall, 1.21 inches; correction of P_2 = 0.01 inch.
[3] Fall, 0.07 inch; corrections = ±0.02 inch.
[4] Fall, 0.12 inch; corrections = +0.04 and +0.02 inch.
[5] Fall, 0.25 inch; corrections = +0.02 and +0.04 inch.

Note.—In order to safeguard the scientific reputation of the late Rev. B. Faura, S. J., but above all to prevent serious consequences which might result, we believe it to be our painful duty to protest on this occasion against a form of aneroid barometer bearing the name of the founder of Manila Observatory, and to warn the seafaring community against confiding in the characteristic feature of said instruments.

In the year 1890 Fr. Faura entrusted to a well-known firm at Paris the specifications of an aneroid which, besides the peculiar arrangement of the face characteristic of the popular Faura barometer, carried on the rim of the same 16 points of the compass, while to the knob at the center were attached three additional pointers forming fixed angles with each other. These were intended to automatically indicate the bearing of the vortex and the course which the ship should steer whenever—the barometer exhibiting readings found within the body of cyclonic storms—the wind index was set in the direction of the prevailing wind. Only six instruments were ordered for experimental purposes and it was understood that the barometer was not to be placed on the market until its reliability had been fully established by actual experience. The instrument did *not* prove satisfactory and, consequently, *has never been made public property.*

To our great astonishment several such barometers, bearing the name of Fr. Faura and constructed by the firm mentioned, have lately been brought to this Observatory for comparison. Our efforts to obtain satisfactory explanations have not been successful and hence we do not know on whom to lay the blame. But we caution those in possession of such instruments not to place any reliance upon the peculiar arrangement. Provided the aneroids are of good quality, they may be used as ordinary Faura barometers, but the best thing which their owners can do is to have two of the additional pointers removed, using the one remaining as the ordinary pointer for marking the reading.

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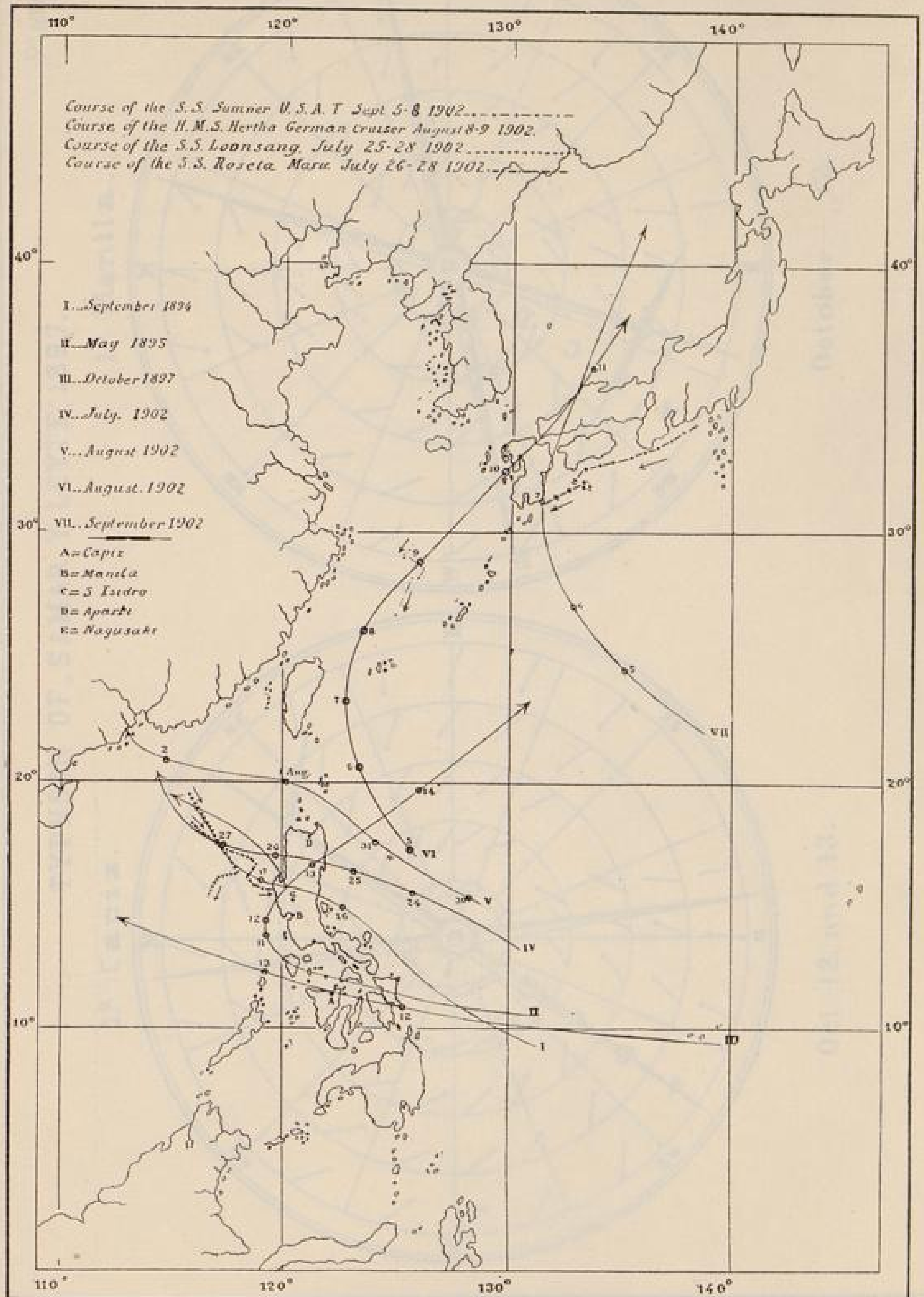
TRACKS OF DIFFERENT TYPHOONS
Plate. XL.

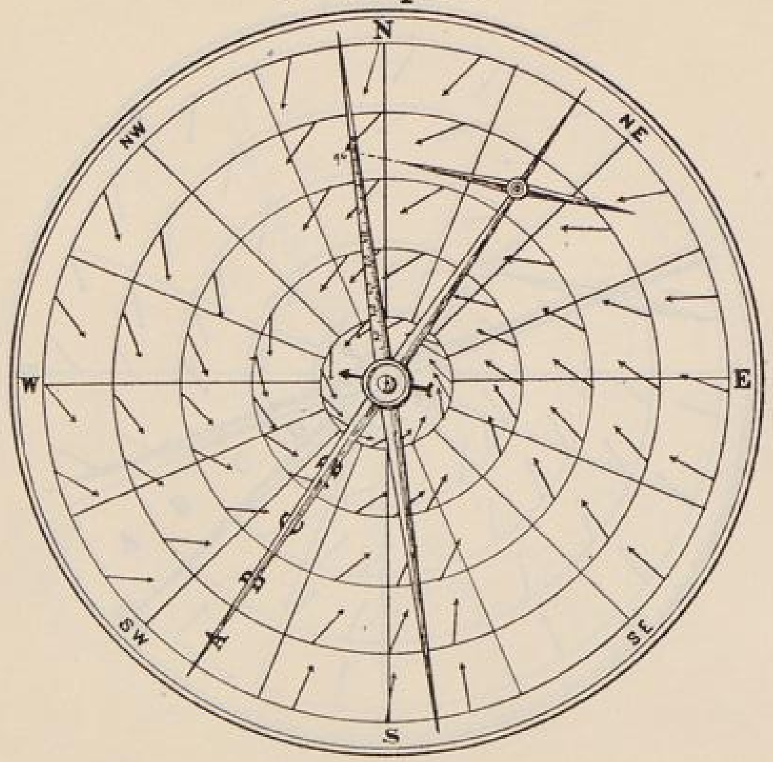
IN CONNECTION WITH THE USE OF THE BAROCYCLONOMETER



Longitude E of Greenwich.

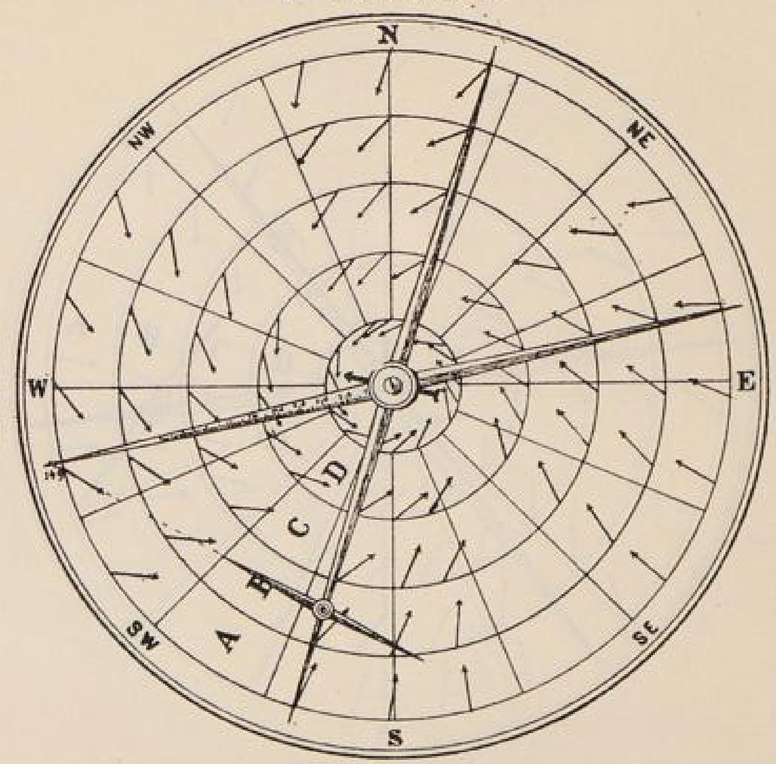
TYPHOON OF „SAMAR Y LEYTE" 1897.

1.ª Capiz.



Oct 12. and 13.

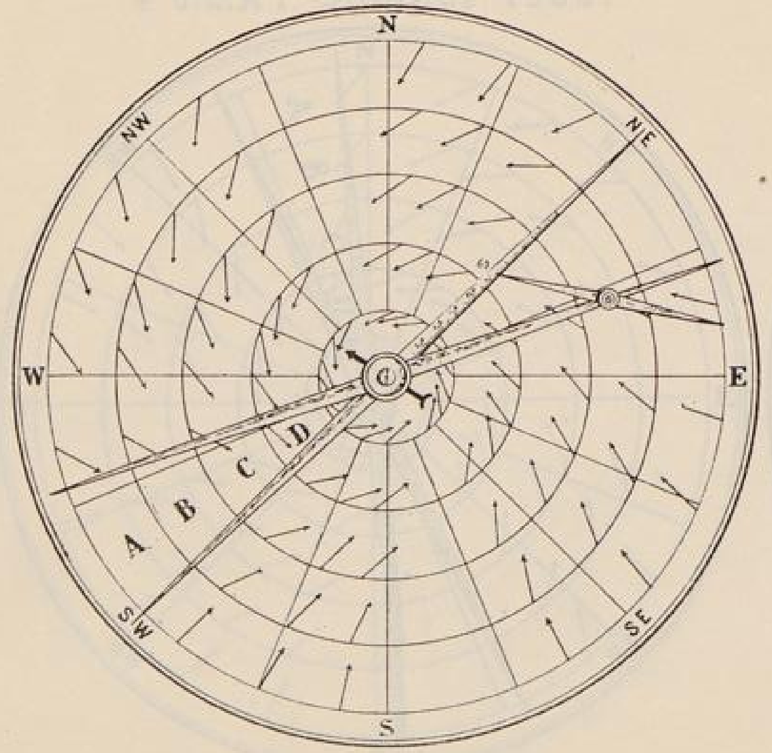
1.ᵇ Manila.



October 13.

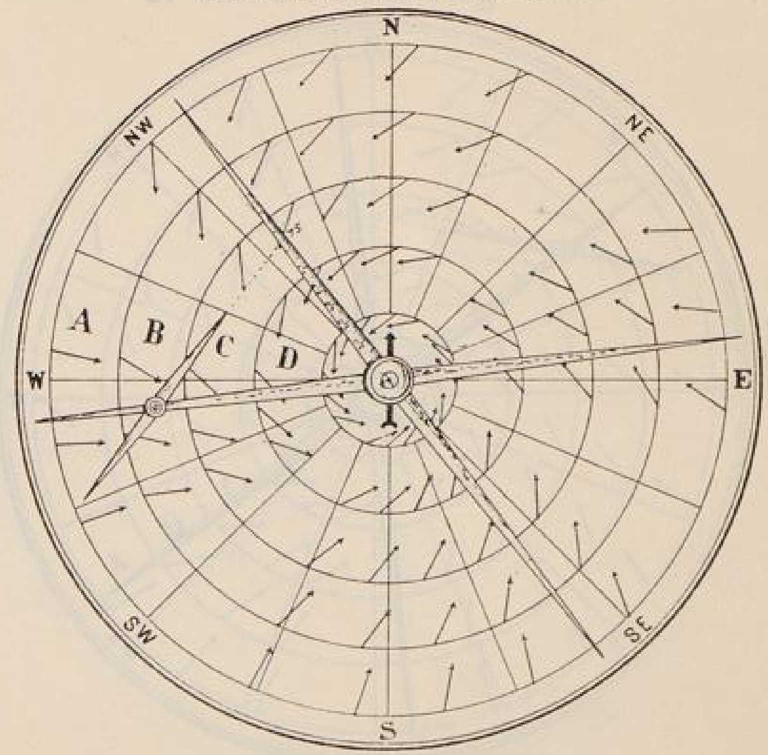
Plate XLII.

2. Manila 1896.



September 16.

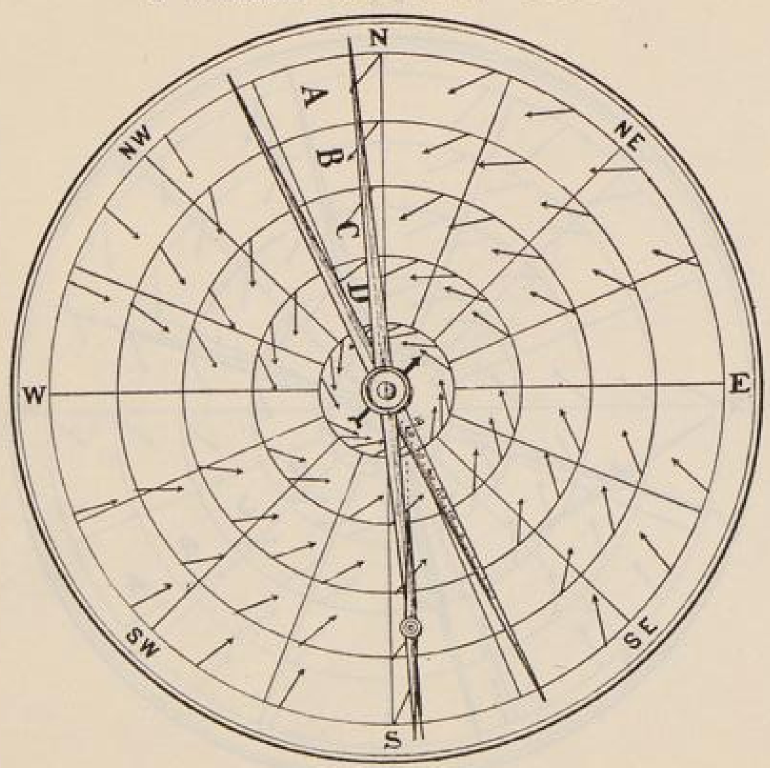
3. San Isidro 1895.



„Gravina" cyclone, May 13.

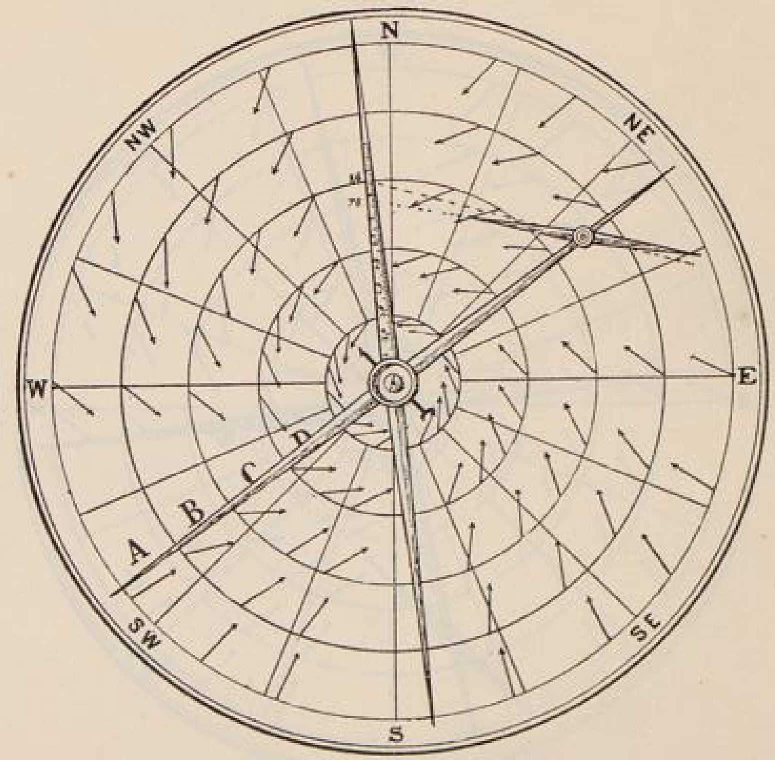
Plate XLIII.

4 U.S.A.T. Sumner 1902.*



September 6.–7.

5a S.S. Loonsang 1902.

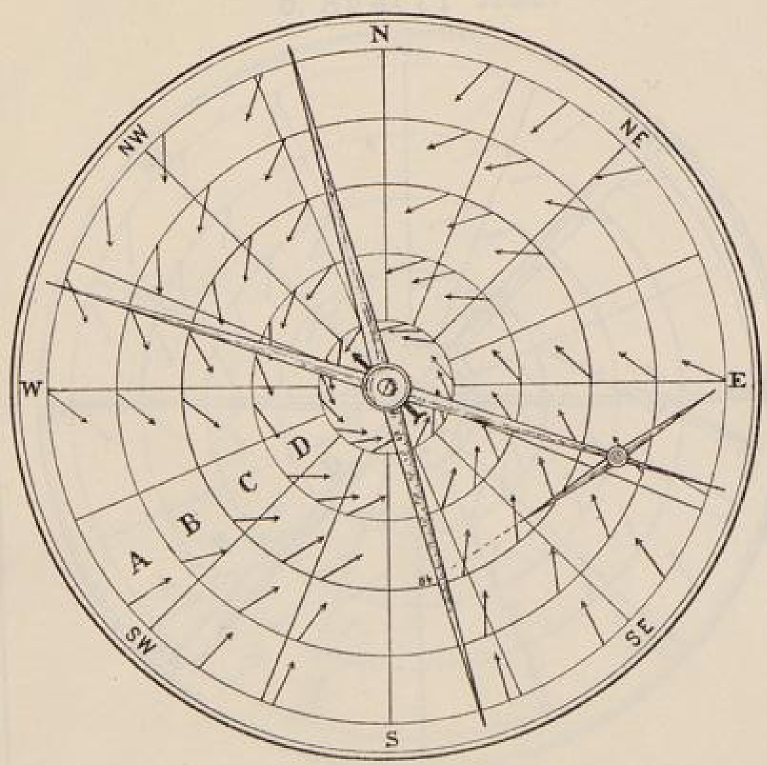


July 26.

Plate XLIV.

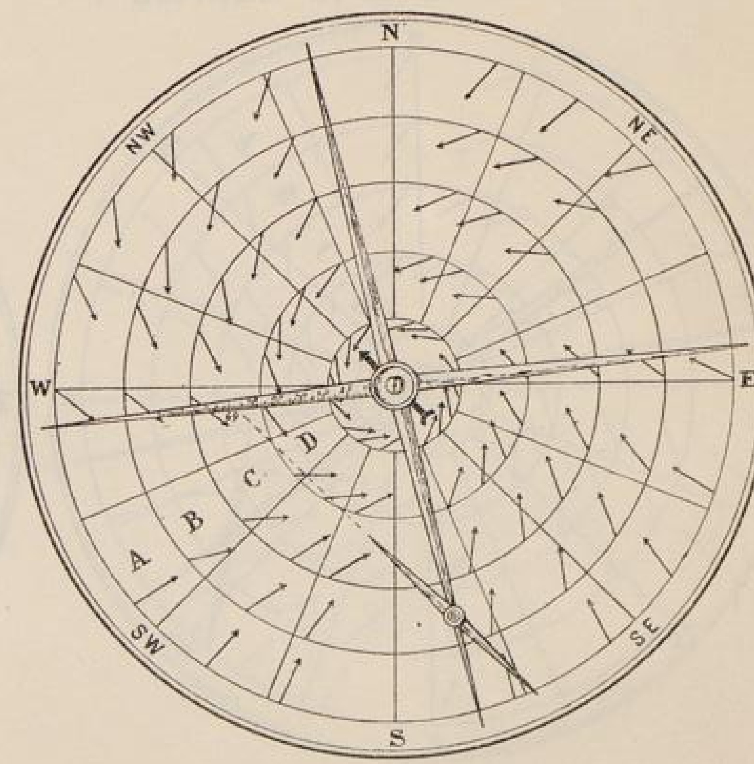
S.S. ROSETA MARU 1902.

5.b



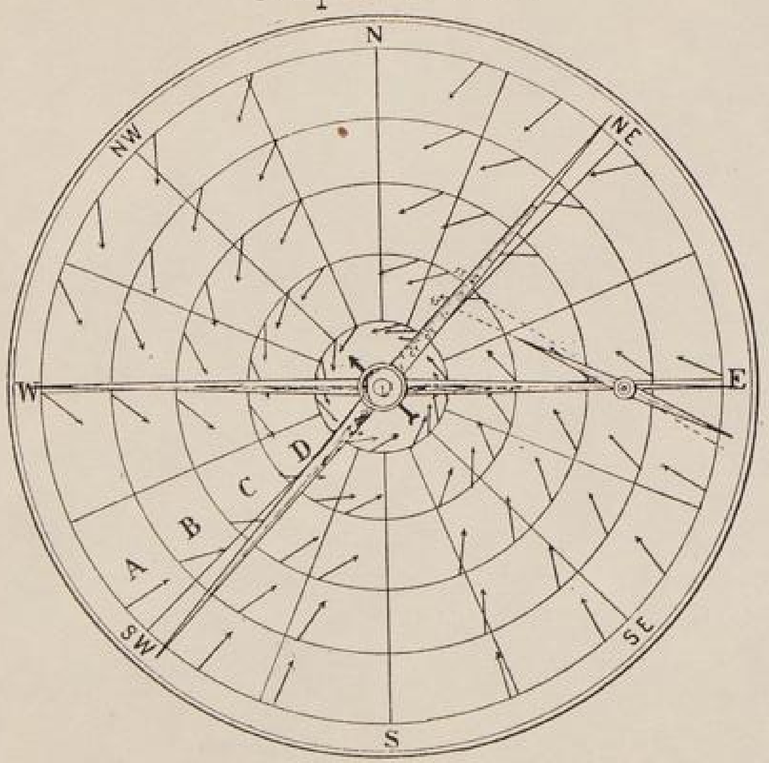
July 26.

5.c



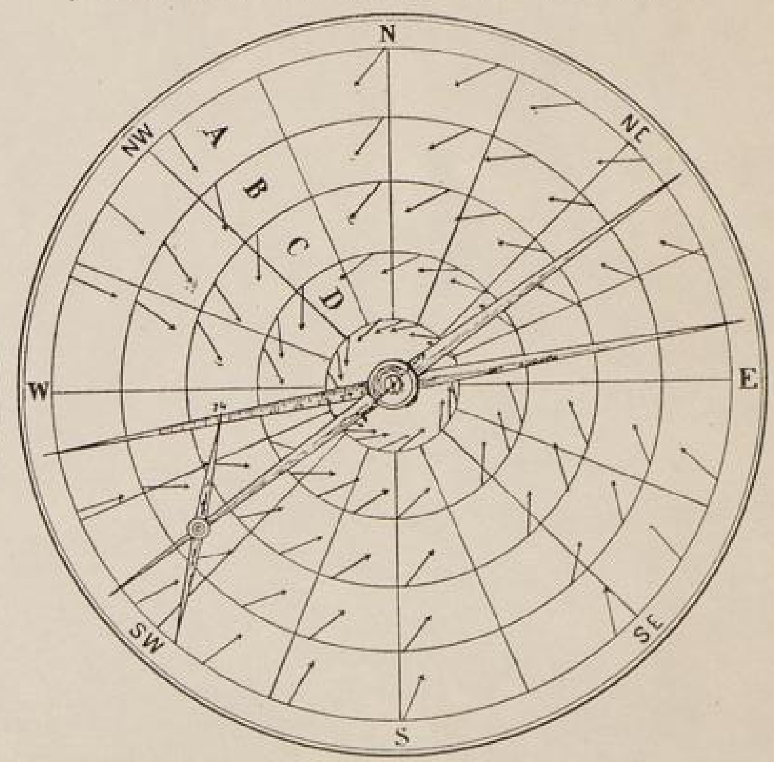
July 27.

6. Aparri 1902.



July 31.–Aug 1.

7. German Cruiser Hertha 1902.



August 9.