Horizontal Pendulum Record obtained
at Mito during a Storm.

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With Pls. VII to IX.

Instances of remarkable inclination of the ground observed in Tokyo during a storm have been described in the *Publications*, No. 21, and the *Bulletin*, Vol. I, No. 4. The present note gives an account of a similar case of the tilting recorded on March 23, 1907, at the meteorological observatory of Mito ($\varphi = 36°23'$ N; $\lambda = 140°28'$ E), with the NS component Omori horizontal pendulum, whose recording cylinder made one revolution in 24 hours, and whose instrumental constants were as follows :—

Pendulum period, when suspended vertically $= T_0 = 1.74$ sec.

Period of Horizontal Pendulum actually set up $= T = 32$ sec.

Multiplication ratio of the pointer $= n = 20$.

Displacement* of the writing index corresponding to the tilting of $1''$

$$= r = L \times n \times \sin 1'' \times \frac{T^2}{T_0^2} = 24.57 \text{ mm.}$$

Fig. 1. (Pl. VII) gives the tiltometer record in question between 10 a.m. and 5 p.m., on the 23rd.

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* In the "Bulletin," No. 4, r has by mistake been defined as the angle of tilting equivalent to 1 mm displacement of the writing index.

Storms on 22-24, March, 1907. From Fig. 2 (Pl. VIII)*, which shows the condition of the weather at 6 a.m. on March 23rd, 1907, it will be observed that there existed simultaneously two cyclones, (I) and (II), whose tracks were parallel to the general course of the Islands, and were over the Pacific Ocean and the Japan Sea respectively. The cyclone (I) appeared on the 21st off the south-eastern coast of Formosa, progressed toward north-east, and approached the south-eastern coast of the Main Island about the noon of the 23rd. The other cyclone, (II), which originated on the 20th at the Yantzse Valley, China, passed through the Tsushima Strait and approached on the 24th the western coast of Hokkaido. Both of these cyclones, which were at first shallow, rapidly increased in intensity with their eastward movement, the storm already extending over the whole of the Main Island on the afternoon of the 22nd. When the centre of the depression (I) approached on the 23rd the peninsula of Awa and Kazusa, the minimum barometric pressure of 744 mm was recorded at Choshi ($\varphi = 35°44'$ N, $\lambda = 140°55'$ E) at 1 p.m. The minimum pressure at Mito was 745.8 mm at 1 p.m. On the Japan Sea side, the minimum pressure, due to the cyclone (II), was 749.9 mm and was observed at Suttsu (province of Iburi, Hokkaido), at 9 p.m., on the 23rd.

Tilting of the ground. A marked southward inclination began to set in about 0h 30m p.m.; the displacement of the re-cording index of the instrument in that direction being 92 mm on record, which corresponds to a level inclination of 3.7″. This tilting was accomplished in the time interval of about 1h 50m, the extreme southward inclination having been reached at 2h 20m

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* The weather map is reproduced from the March (1907) number of the " Kisho Yoran," published by the Central Meteorological Observatory.

p.m. Thereafter the northward inclination began to set in.

Thus it will be observed that the commencement of the sudden southward tilting was at about 30 min. before the epoch of the minimum barometric pressure at Choshi and Mito; the passage of the centre of cyclone producing, as in the case of the storm on Oct. 10th and 11th, 1904, not an elevation but the depression of the ground. This is probably due to the fact that the deep barometric cyclone was accompanied, or rather followed, by an increase of the height of sea water, to an amount greater than the equivalent of the barometric fall, as explained in the next §.

Mareogram at Choshi. Fig. 3 (Pl. IX) is a reproduction of the tide gauge diagram obtained on March 22nd and 23rd, 1907, at Choshi (province of Shimosa), which place is situated at the month of the River Tone, near Cape Inuboe, at a distance of about 80 km to the SES of Mito*. The disturbances of the water, consisting in the secondary undulations proper to the coast of observation began to become marked from about $4\frac{1}{2}$ a.m. on the 23rd, continuing to increase till midnight of the same day. The level of the sea also began to rise, the greatest limit being reached at about 2 p.m. to a few minutes after 3 p.m., when the water thus abnormally accumulated was about $2\frac{1}{2}$ *shaku* (=75.8 cm) higher than the level according to the usual tide movement, and 1.12 *shaku* (=34.0 cm) than the highest water during the preceding day. The time of the greatest water accumulation at Choshi thus nearly coincided with the moment of the maximum southward tilting at Mito. The difference of the highest mean level at about 3 p.m. (23rd) over that of the

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* For the copy of the mareogram I am indebted to Prof. Dr. T. Kondo of the Interior Department.

mean low water occurring about 3 honrs earlier is some 1.45 *shaku* (=44 cm), which may be taken as the differential increase of the height of the sea level near the position of the cyclone over that in the neighbouring portions of the ocean. As the difference of the barometric pressure at the minimum centre and the coast near it was probably about 10 mm, or about 14 cm of water column, we see that the resultant relative pressure at the ocean bottom immediately after the passage of the cyclone centre is increased by an accumulation of water nearly 30 cm in height, extended over the sea surface of no insignificant dimension. This probably accounts for the tilting of the ground toward the centre of barometric depression, when the path of the latter is over the Pacific.

Fig. 1. Omori Horizontal Pendulum (Tiltometer) Diagram.

Mito, March 23, 1907. Pendulum Period=32 sec.

Each sign (×) marks the disturbance communicated to the writing pointer at the time of an hour signal.
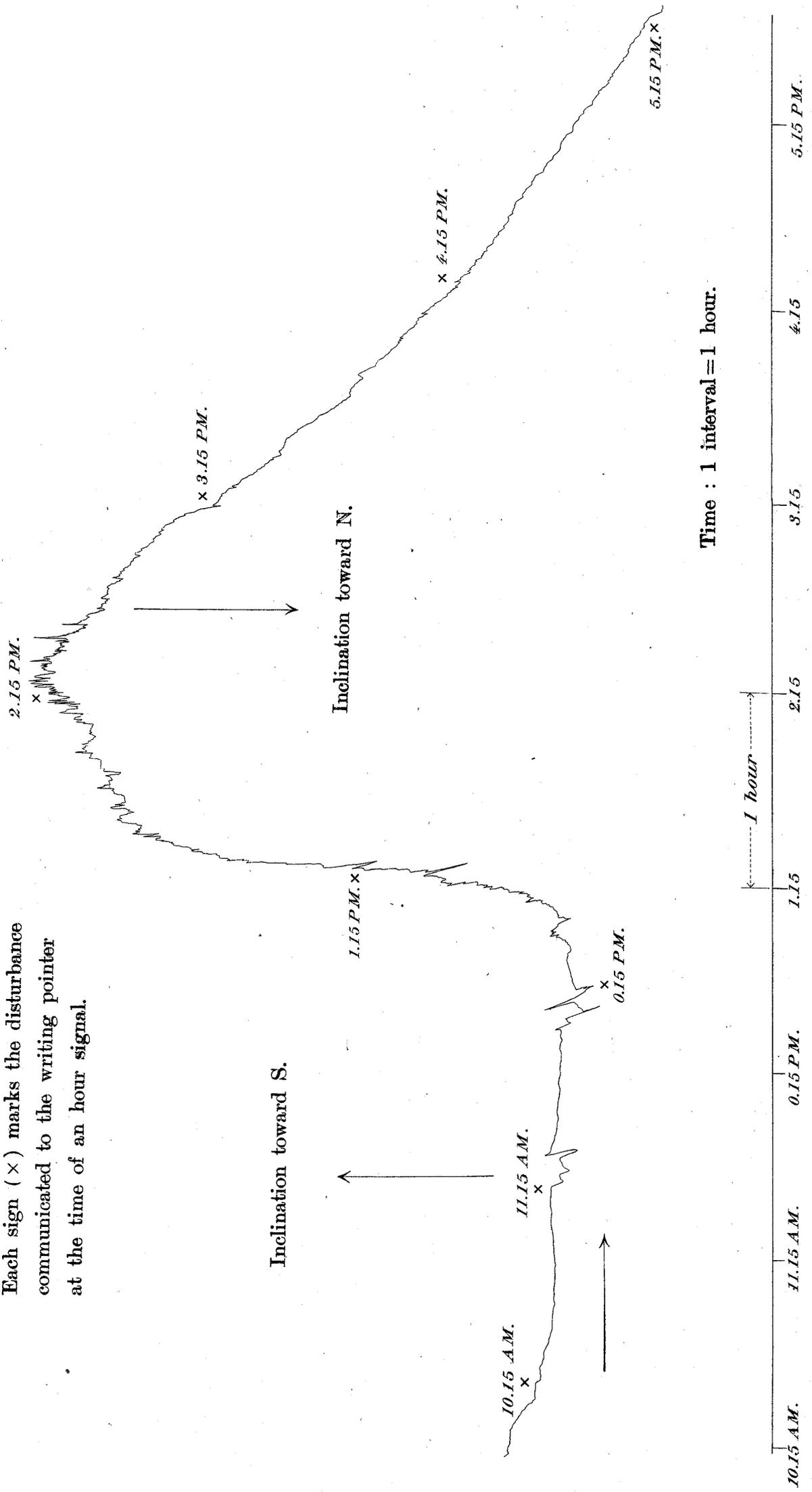
Inclination toward N.

Inclination toward S.

10.15 A.M.
×

11.15 A.M.
×

0.15 P.M.
×

1.15 P.M.×

2.15 P.M.
×

× 3.15 P.M.

× 4.15 P.M.

5.15 P.M.×

Time : 1 interval=1 hour.

--- 1 hour ---

10.15 A.M.   11.15 A.M.   0.15 P.M.   1.15   2.15   3.15   4.15   5.15 P.M.

Fig. 2. Weather Map. March 23, 1907 ; 6 A.M.

The dotted lines (I) and (II) give the paths of the
two cyclone centres, whose positions at 6 A.M. of the
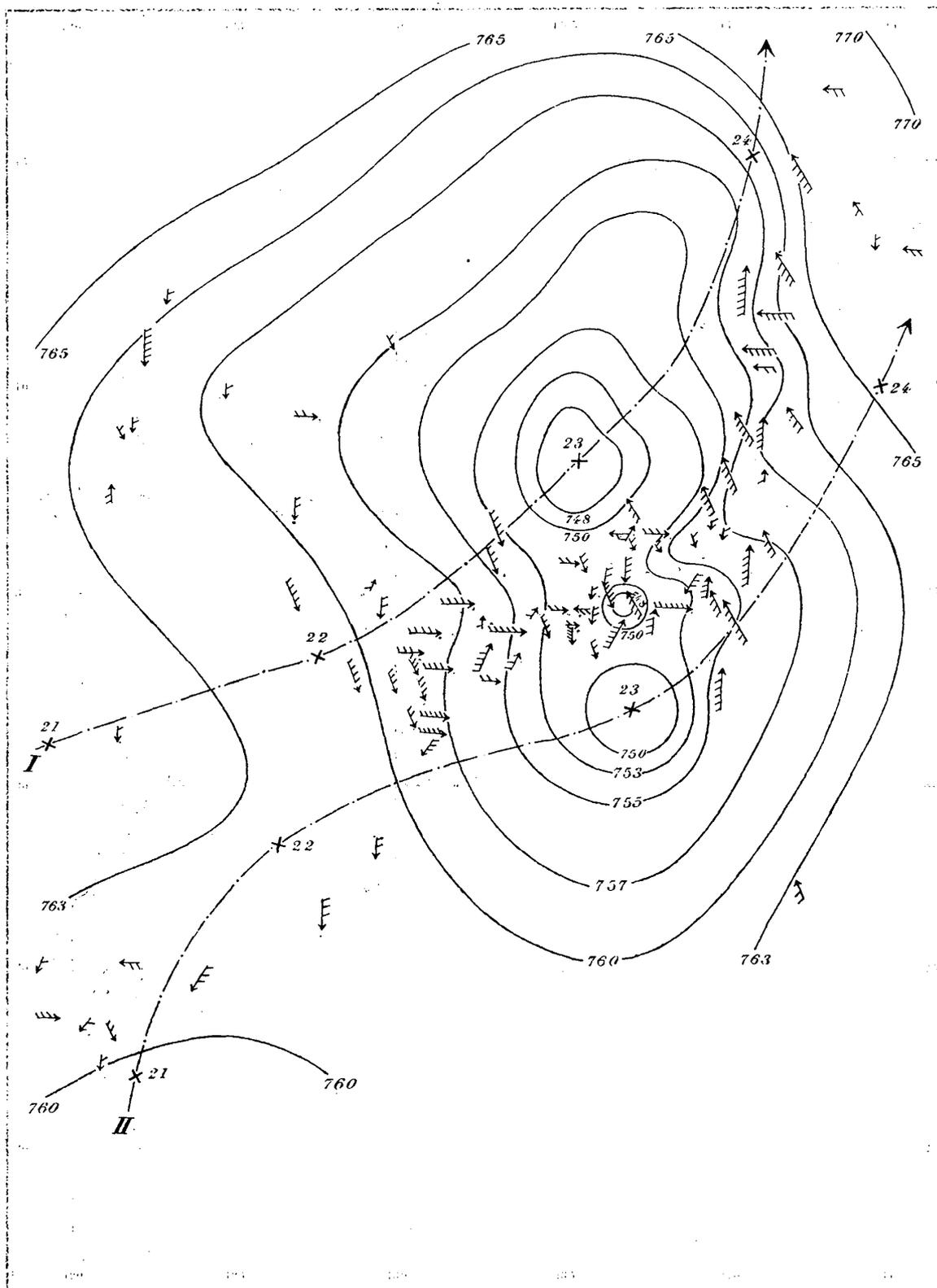successive days are each indicated by a small cross (×).

Pl. IX.

Fig. 3. Mareogram at Chōshi. Nov. 22nd and 23rd, 1907.

(Height of water is given in *shaku*, 1 *shaku* = $\frac{1}{3.3}$ × metre).

The dotted line indicates the approximate height variation, which the sea level would have assumed if the storm did not occur.

(The right-hand end of the lower figure is continued to the left-hand end of the upper.)