Seismographic Diagrams of the Local Earthquake of June 11, 1907.*

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1. Area of Disturbance. The earthquake of June 11, 1907, at $8^h\ 59^m\ 21^s$ a.m. (Hongō, Tokyo) was felt moderately or strongly in the vicinity of Tokyo over an area about 200 km in length and about 100 km in width. The area, within which the motion was sensible, stretched from near the northern end of the Main Island to the vicinity of Osaka, over a distance of nearly 900 km. (See Fig. 1, Pl. XLIV.) In Tokyo, the earthquake was of a moderate intensity, and, although no damage was caused, it was the strongest next to the severe shock of Feb. 24, 1906.

2. Position of the Eqke Origin. The durations of the preliminary tremor at Tokyo, Mito, and Mount Tsukuba, were respectively 8.5 sec., 9 sec., and 7.2 sec. The circles drawn about these places and centres with radii equal to the corresponding epicentral distances‡, meet each other near the origin of disturbance, whose approximate position is $\lambda=140°45'$, $\varphi=35°30'$, at about 100 km to S78°E of Tokyo. (See Fig. 1.) In Tokyo, the shock was preceded by a slight, but distinct sound.

3. Microseismograph Records. Figs. 2, 3, and 4 (Pl. XLV) give the EW, vertical, and NS component diagrams furnished by

* The times are given in the 1st Normal Japan Time, namely, that of 135° E.

‡ Calculated according to the formula $x^{km}=7.27\ y^{sec.}+38^{km}$, where x is the epicentral distance and y is the duration of the total preliminary tremor.

the respective microseismographs. The instrumental constants are:—

EW.....	Multiplication	=10;	Pendulum period	=28 sec.
Vertical	„	=12;	„	=4 „
NS	„	=30;	„	=48.5

It will be observed that the preliminary tremor was suddenly followed by the maximum vibration, the two displacements of the latter being as follows:—

1st motion=5.1 mm, towards S70°E;
2nd „ =6.6 „ (maximum), towards N63°W.

Thus the very first displacement of the principal portion took place approximately towards the earthquake origin, while the counter, or maximum, displacement was directed away from the latter. The vibration in question belongs evidently to the "longitudinal wave," its mean direction of S67°E—N67°W being not much different from the epicentral direction from Tokyo. For the next 1^m 20^s, the motion remained active, the total duration being about 20 min. The comparative shortness of the duration, in spite of the large amplitude of the principal vibration, is the characteristic of a local shock.

For the sake of comparison, I give in Fig. 4 (Pl. XLV) the EW component diagram of the moderate earthquake of June 23, 1902, at 7^h 42^m 42^s A.M., recorded at Hongō by the same instrument as in Fig. 2. It will be observed that Figs. 2 and 4 are almost perfectly identical to one another; the two displacements composing the maximum vibration at the commencement of the principal portion of the earthquake here considered being respectively 5.7 mm towards E, and 7.0 mm towards W.

Figs. 6, 7, 8, and 9 (Pl. XLVI) are the EW component

diagrams of the earthquake (June 11, 1907) furnished by horizontal pendulums, as follows:—

Figs. 6...Hongo (Tokyo). Multiplication=30; Pendulum period=41.5 sec.
Figs. 7... „ („) „ =15; „ =61.5 „
Figs. 8...Hitotsubashi(„) „ =10; „ =31.1 „
Figs. 9...Mito. „ =20; „ =28.8 „

4. Macroseismograph Records. Fig. 10, Pl. XLVII, is the record furnished by a Gray Milne type macroseismograph, set up in the Seismological Institute, the magnification of the EW, NS and vertical components being respectively 5, 5, and 8. The numerals, 1, 2, 3, and 4, indicate corresponding epochs in the three components. The duration was in this case, about 6 min. The large movement at the commencement of the principal portion was as follows:—

Resultant hor. motion=6.8 min., towards N50°W.
Vertical motion =0.8 mm upwards.

This result is nearly similar to that indicated by the microseismographs (§3). Only the first displacement, corresponding to a single amplitude, is here very imperfectly shown, on account of the length of its period and the friction of the instrument. The subsequent and principal macro-seismic vibrations* were as follows:—

Max $2a=1.6$ *mm*, $T=1.6$ sec.
„ „ , $T=0.72$ „

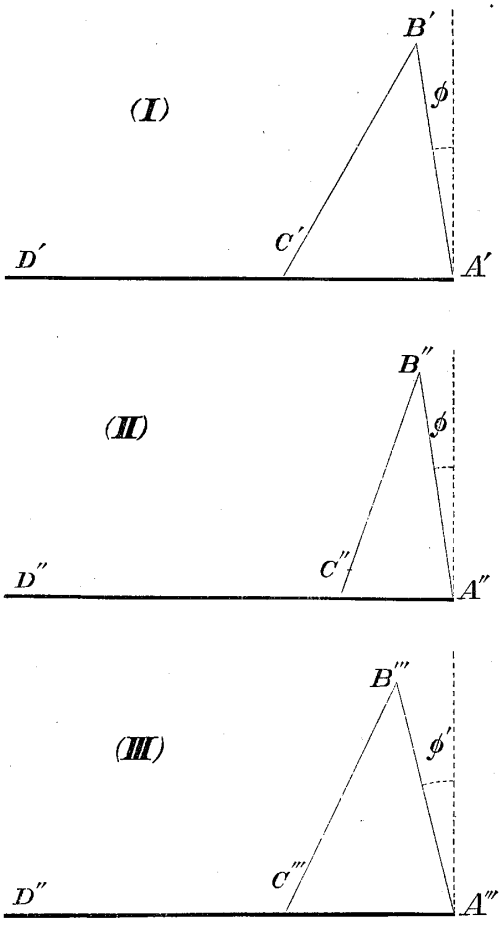
The period of the "ripples," or small sharp vibrations, was 0.20 sec.

Fig. 11 (Pl. XLVIII), is the macroseismographic record obtained at Hitotsubashi (Tokyo), the EW, NS, and vertical components being multiplied 3, 4, and 2 times, respectively.

* T and $2a$ denote as usual the complete period and the double amplitude, respectively.

The numerals, 1, 2, 3, and 4, indicate corresponding epochs in the three components. It will be observed that the movements of the macroseismic character at Hitotsubashi is more regular and much greater than at Hongo; this being the consequence of the extreme softness of the ground at the former place.

5. Tiltometer Records. The following is the principle of the experiments made to test the existence or non-existence of tilting in the ordinary or macroseismic motion, which I have carried on since 1897 at the Seismological Institute. As diagrammatically shown in the accompanying figure, let there be three horizontal pendulums, I, II, and III, in which C′, C″, C‴ are the heavy bobs; B′C′, B″C″, B‴C‴ the ties; A′C′, A″C″, A‴C‴ the struts; and C′D′, C″D″, C‴D‴ the writing pointers; the lengths A′D′ and A″D″ being equal to one another. Further, let the two pendulums, I and II, have a common angle ($=\varphi$) of inclination of the pendulum axis to the vertical, the ratios of multiplication $\frac{A'C'}{C'D'}$ and $\frac{A''C''}{C''D''}$ being unequal; while the two pendulums, I and III, have equal ratios of multiplication, $\frac{A'C'}{C'D'}$ and $\frac{A'''C'''}{C'''D'''}$, but unequal angels of inclination of the pendulum axes, φ and φ'. The three pendulums are placed with their planes parallel to one another. Thus the first two pendulums would have an equal



sensibility for a tilting motion, but different magnifications for a horizontal motion; while the first and third pendulums have an equal magnification for a horizontal motion, but different sensibilities for a tilting motion.

Fig. 12 (Pl. XLIX) is the record of the EW component motion obtained on the occasion of the earthquake of June 11, 1907, by one of the machines composed, according to the principle above explained, of the three pendulums A, B, and C, the instrumental constants being as follows:—

Pendulum.	Length of Strut.	Total length of Strut and Pointer.	Multiplication(for Hor. Motion.)	T_0	T	$\varphi=\frac{T_0^2}{T^2}$
	cm	cm		sec.	sec.	
A	12	48	4	0.70	4.36	$\varphi_A=\varphi_B$
B	7	48	7	0.51	3.31	$\varphi_B=\varphi_A$
C	7	28	4	0.53	2.50	φ_C

In the above table T_0 and T denote respectively the complete period of vibration of each pendulum when suspended vertically and when actually set up as a horizontal pendulum. The displacement of the writing index of the pointer corresponding to a tilting α is, in each case, given by the formula.

$$\gamma\ (\text{sensibility})=l\times\frac{\alpha}{\varphi}.$$

From the adjustments of the three pendulums as given in the above table, we arrive at the following relations:—

$$\varphi\ (\text{for } \boldsymbol{C})=1.74\ \varphi\ (\text{for } \boldsymbol{A} \text{ and } \boldsymbol{B}).$$

$$\gamma\ (\text{for } \boldsymbol{A} \text{ and } \boldsymbol{B})=3\gamma\ (\text{for } \boldsymbol{C}).$$

Thus the two pendulums A and B ought to give, for a tilting of the ground, a record three times larger than the pendulum C;

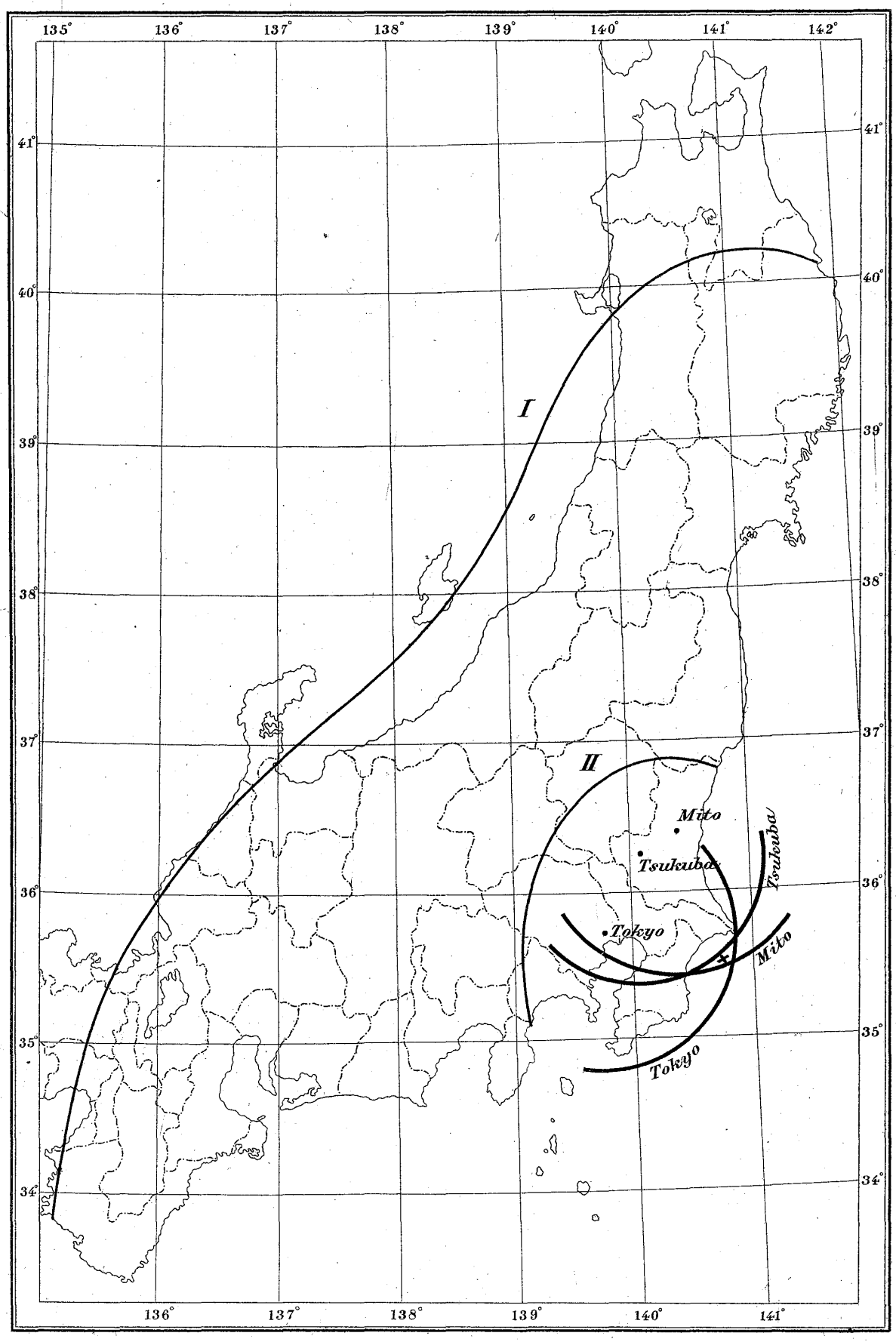
while each of the two pendulums A and C gives, for the horizontal motion, a record equal to 4/7 of that of the pendulum B.

Although different amounts of the friction in the three pendulums evidently interfered to some extent with the accuracy of the records, Pl. XLIX indicates, as well as the diagrams obtained on other occasions, that the tilting element in the ordinary earthquake motion is, if any, very slight in amount.*

The First Report on this experiment was published in No. 32 of the Japanese *Reports* of the Imp. Earthquake Inv. Comm. (1909).

Fig. 1. Earthquake of June 11, 1907.

(×).....Eqke Origin.
(I) .....Boundary of Area of Sensible Motion.
(II) ..... „ „ „ Strong or Moderate Motion.



Figs. 2, 3, and 4. Earthquake of June 11, 1907. Observed at Hongo, Tokyo.

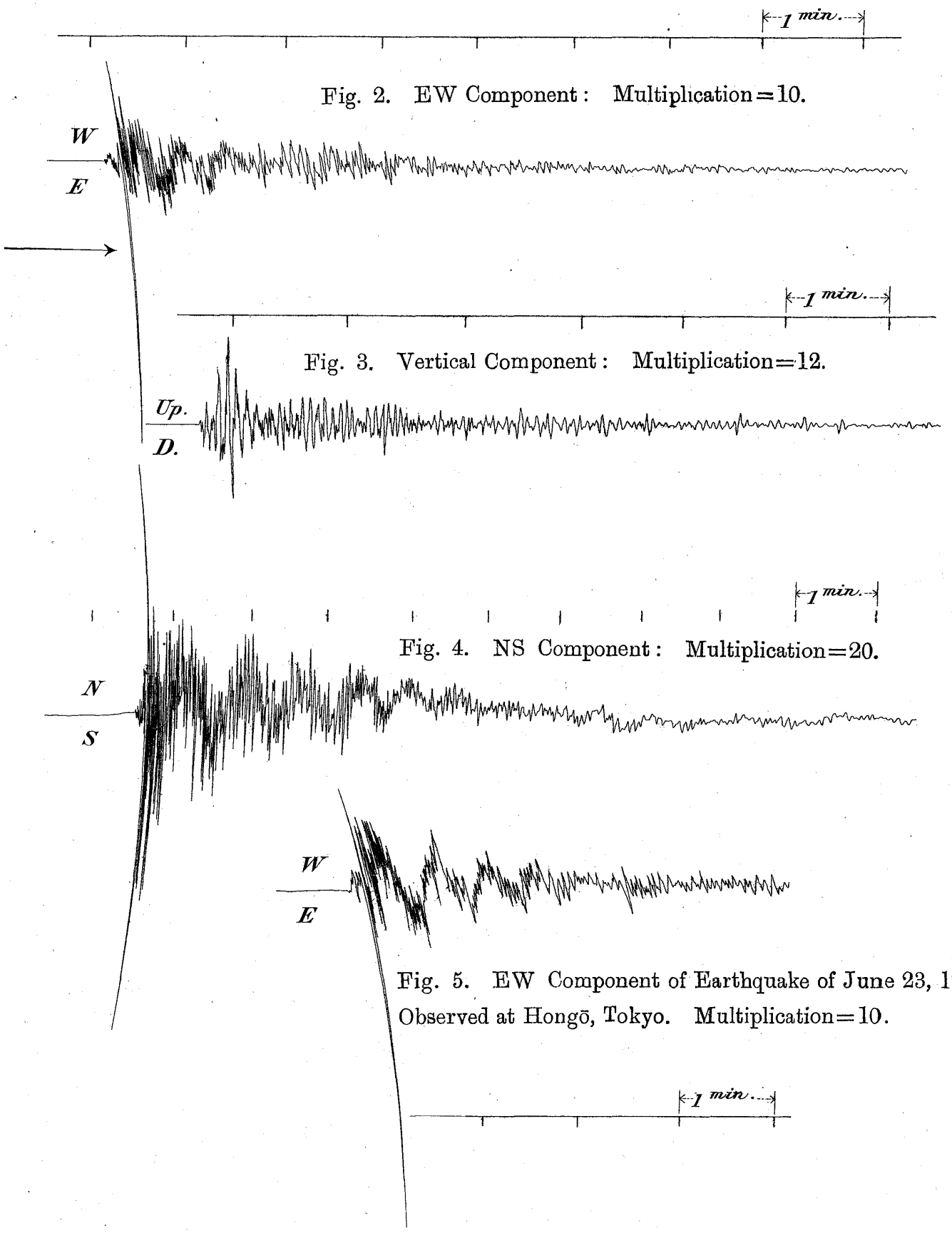


Fig. 2. EW Component: Multiplication=10.

Fig. 3. Vertical Component: Multiplication=12.

Fig. 4. NS Component: Multiplication=20.

Fig. 5. EW Component of Earthquake of June 23, 1902. Observed at Hongō, Tokyo. Multiplication=10.

Horizontal Pendulum Diagrams of Eqke of June 11, 1907.

Fig. 6. EW Component, Hongō.
Multiplication=30.

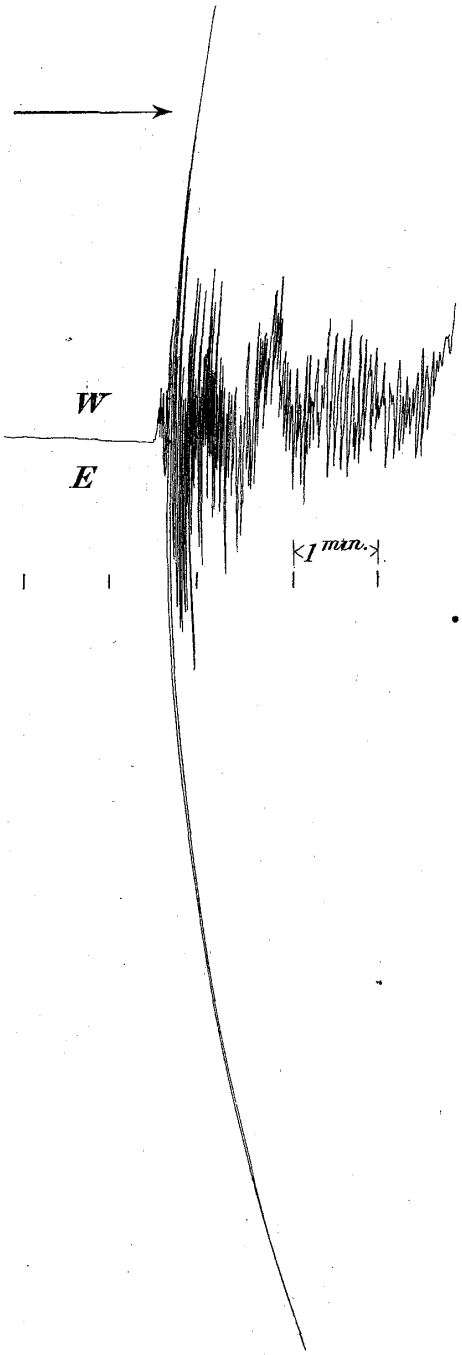


Fig. 7. EW Component, Hongō.
Multiplication=15.

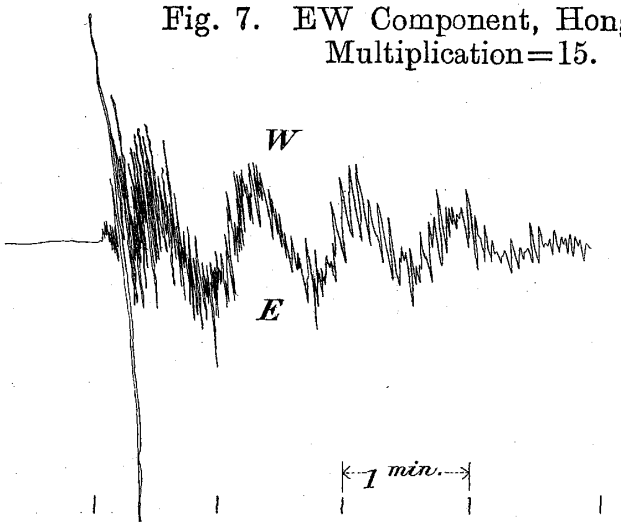


Fig. 9.
EW Component, Mito.
Multiplication=20.

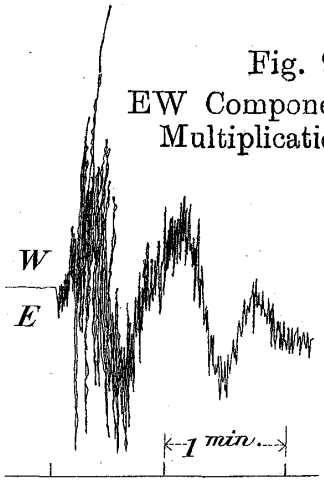


Fig. 8. EW Component, Hitotsubashi.
Multiplication=10.

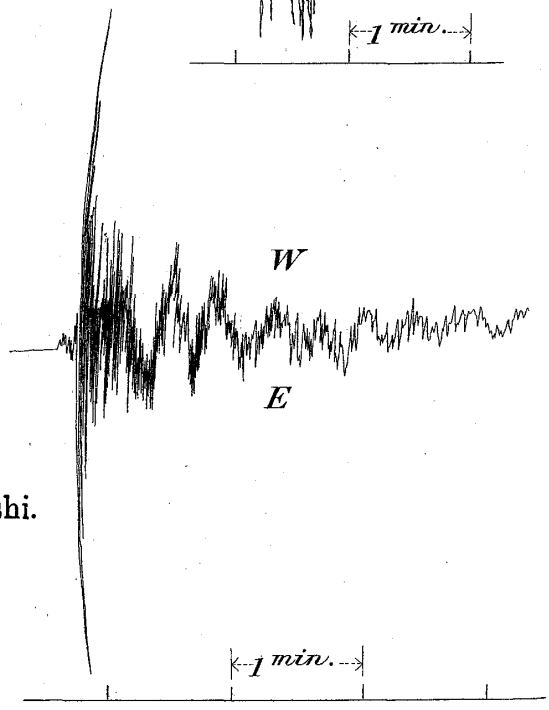


Fig. 10. Tokyo Earthquake of June 11, 1907. (Intensity, *Moderate.*)

Observed at Hongō, Tokyo. Gray Milne Type Seismograph.

Multiplication for EW Component = 5
„ NS Component = 5
Vertical Component = 8

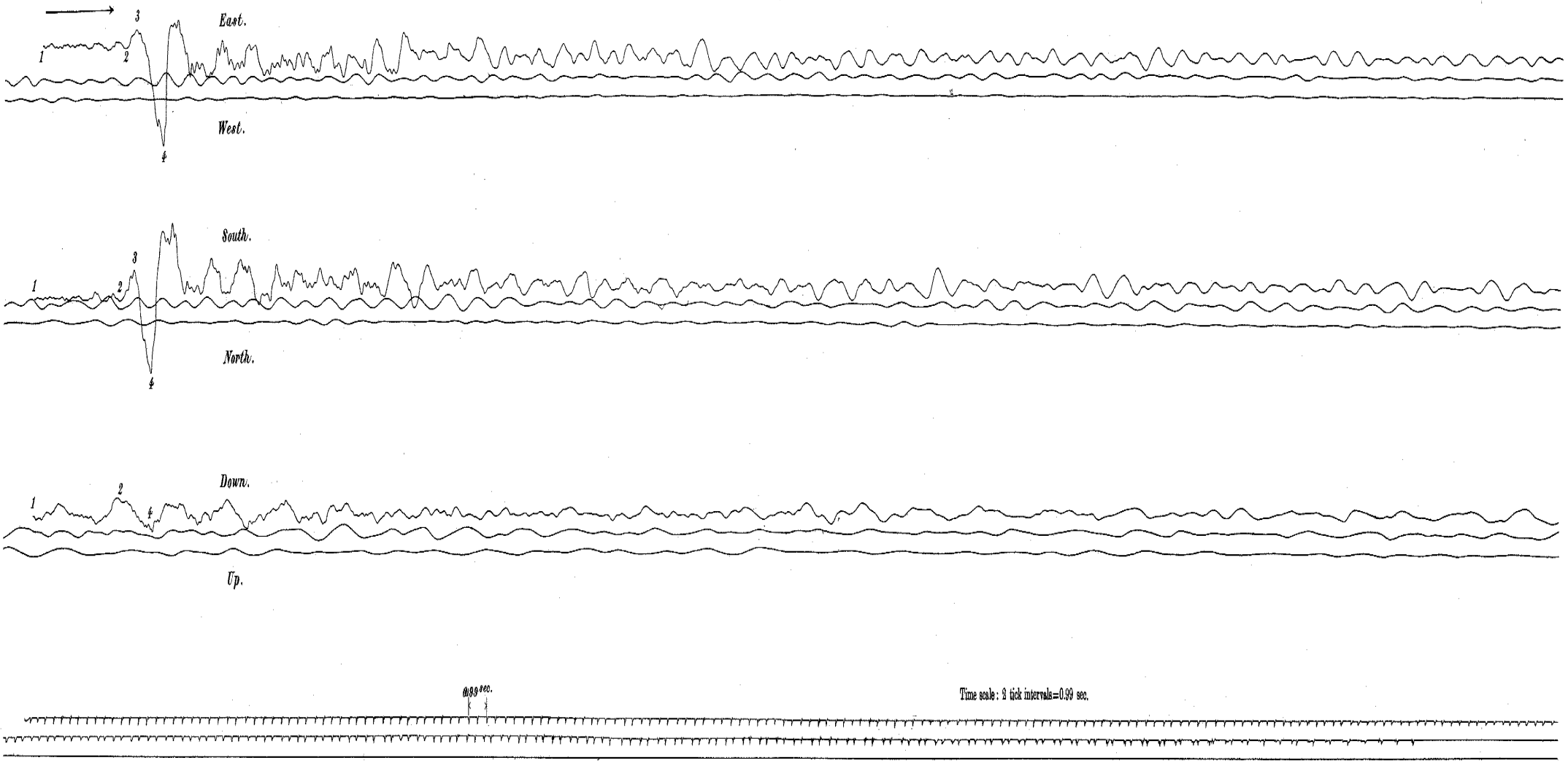


Fig. 11. Tokyo Earthquake of June 11, 1907. (Intensity, *Moderate.*)

Observed at Hitotsubashi, Tokyo. Gray Milne Type Seismograph.

Multiplication for EW Component = 3
" " NS Component = 4
Vertical Component = 2

Period of Time Marking Pendulum = 0.72 sec.

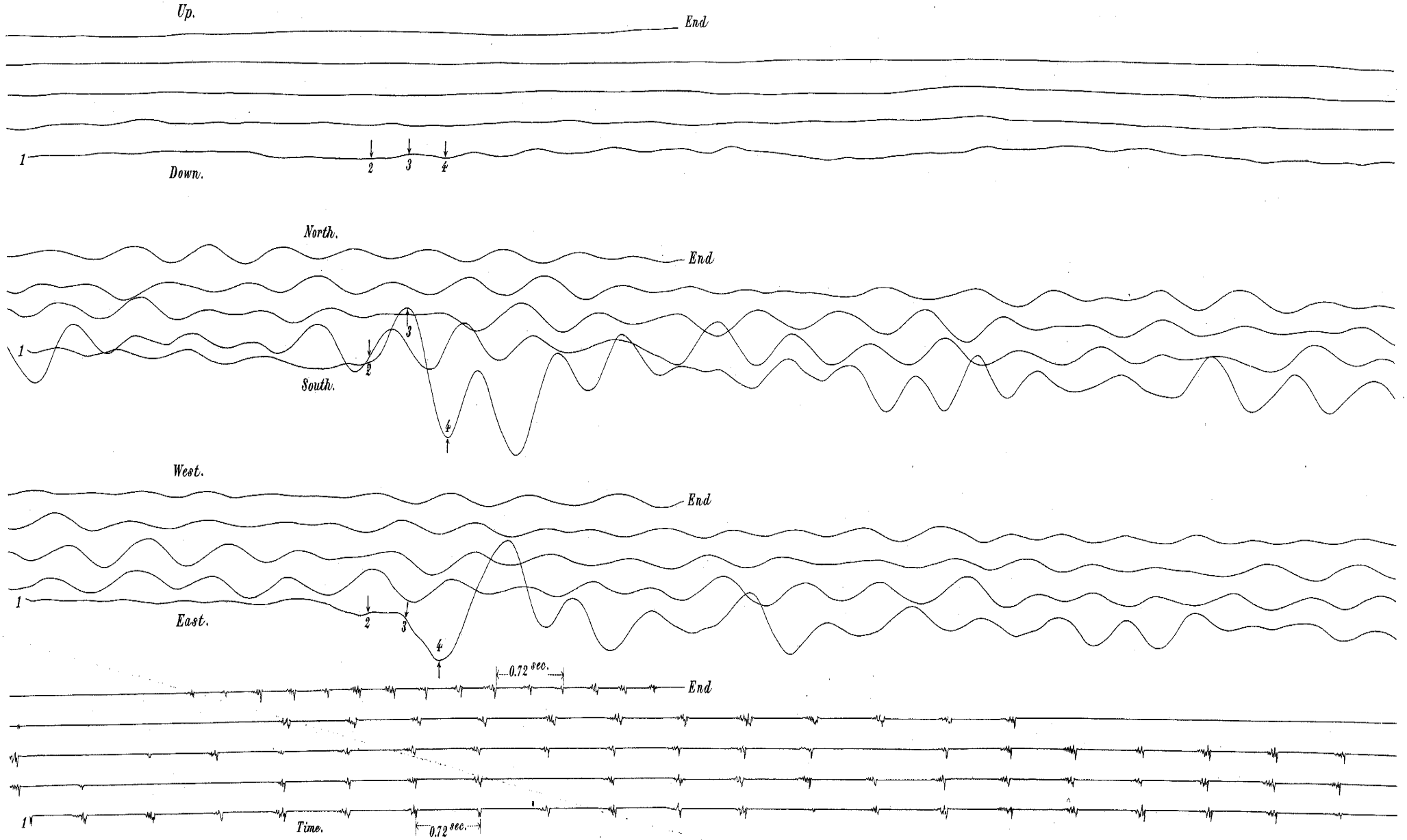


Fig. 12. Tiltometer Diagram of the Tokyo Earthquake of June 11, 1907.