

Note on the Tokyo Earthquake of Nov. 22, 1907.

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With Pls. IV-VI.

The earthquake of Nov. 22, 1907, at 2h 17m A.M., was one of the strongest felt in Tokyo since the semi-destructive shock of June 20, 1894. The disturbance, which caused no damage, was a local one, and the severity of motion in Tokyo was partly due to the proximity of the latter to the earthquake origin. The total duration of the records furnished by the teleseismographs in Tokyo was only 24 min., while that in Kobe, where the shock was insensible, was 12 min.

Area of disturbance. As shown in Fig. 1 (Pl. IV), the earthquake was sensible within a land area about 75 km in length and 300 km in width. The area of moderate motion was nearly circular, with a mean diameter of about 320 km. Again, the area of strong motion is a small ellipse in the NW-SE direction, whose major and minor axes are respectively about 130 and 85 km. in length. It may be remarked that the south-eastern half of this meizoseismal ellipse coincides with the alluvial plain of Musashi, where the motion is much intensified owing to the softness of the ground; the centre of the ellipse not necessarily corresponding to the real earthquake epicentre.

The position of the latter seems in fact to be much eccentric and near the north-western end of the major axis, as considered in the next §.

Duration of preliminary tremor and position of epicentre. The durations of the preliminary tremor observed instrumentally at Tokyo and 7 other stations were as given in the following table.

Name of Station.	Latitude.	Longitude.	Duration of the total preliminary tremor.	Calculated epicentral distance.
(i) Tokyo.	35°43' N	139°46' E	7.5 sec.	92 km.
{ Mito.	36 23	140 28	10.0	110
{ Tsukuba.	36 13	140 06	10.0	110
(ii) <i>Mean</i> .....	.....	.....	10.0	110
{ Miyako.	39 38	141 59	50.0	400
{ Ishinomaki.	38 26	141 19	42.5	347
(iii) <i>Mean</i> .....	.....	.....	46.3	374
(iv) Nagano.	36 40	138 10	21.8	197
{ Kobe.	34 41	135 11	48.6	391
{ Osaka.	34 42	135 31	50.0	400
(v) <i>Mean</i> .....	.....	.....	49.3	396

The duration of the preliminary tremor has been determined in the usual way from the different seismograms, with the exception of those obtained in Tokyo. The phase in question for the latter place has been taken in regard to the vibrations of macro-seismic nature.

The figures in the last column of the above table have been calculated by the formula, $x \text{ km} = 7.27 y \text{ sec.} + 38$, in which x and y are respectively the epicentral distance and the duration of the preliminary tremor. Drawing on the map (Fig. 1) five circles with radii equal to the calculated distances of (i) to (v) about the respective positions as centres, we see that four of these meet near one another in the southern part of the province of Kotsuke. The probable position of the epicentre, indicated in the figure by a small cross (\times), is situated in the northern part of the province of Musashi, namely, at about latitude $36^{\circ}\frac{1}{4}$ N, and longitude $139^{\circ}\frac{3}{4}$ E, at a distance of about 55 km to the north-west of Tokyo.

Observation in Tokyo. Time of Occurrence = 2h 17m 35s A.M.

Initial slow displacement. The seismograms furnished by the long-period horizontal pendulum instruments in Tokyo, three of which are reproduced in Pl. VI, are interesting in showing apparently no preliminary tremor, but beginning at once with a large slow vibration of period of about 7.5 sec., followed by a number of the proper pendulum oscillations. The initial displacements in the EW and NS directions, meaned from the different diagrams, are as follows:—

$$\left\{ \begin{array}{l} \text{Motion toward East} = 3.3 \text{ mm.} \\ \text{,, ,, North} = 3.2 \text{ ,,} \\ \text{Resultant displacement} = 4.6 \text{ mm; Direction, N } 46^{\circ} \text{ E.} \end{array} \right.$$

Thus it will be observed that the direction of the initial (slow) motion was in this case approximately perpendicular to the line joining Tokyo with the earthquake origin, the vibration probably belonging to the category of the transverse wave*. A circumstance,

* See also an account of the earthquake of Jan. 21, 1906, which originated off the south-eastern coast of the Main Island. The *Bulletin*, Vol. I, p. 145.

which gives support to this latter supposition, is that the horizontal pendulum diagrams obtained at the other stations, whose epicentral distances were greater than that of Tokyo, showed no distinct slow vibration at the commencement, the preliminary tremor being generally well marked, due possibly to the slower transit rate and the consequent retardation of the transverse wave. The total duration of the earthquake motion in Tokyo was 24 min.

The results of studies on the nature of the vibrations occurring at the commencement of an earthquake, observed near the origin of disturbance, will be published in the *Bulletin* from time to time, a general discussion on this subject being reserved for a future occasion.

Macroseismograph record obtained at Hitotsubashi (Tokyo). Fig. 2 (Pl. V) gives the preliminary tremor and the earlier and most active part of the principal portion of the earthquake motion as recorded by an ordinary Gray-Ewing-Milne type seismograph, which magnifies the EW, NS, and vertical components 3, 4, and 2 times respectively. It will be observed that in this macro-seismogram, which does not show the slow vibrations existing in the earthquake motion, the preliminary tremor is well defined, the principal portion beginning with conspicuous movements of large amplitude. In the following description of the seismogram, the complete period and the range of motion (double amplitude) are denoted by the symbols T and $2a$ respectively.

Horizontal Motion.

The motion was sensible for about 2 min.

Preliminary tremor. The movements were as follows:—

(NS) $T = 0.85$ sec., Max. $2a = 1.00$ mm.

(EW) $T = 0.82$ „ Max. $2a = 0.73$ „

Principal portion. The motion was about 3 times greater in the NS than in the EW component, this being contrary to what is usually the case with strong Tokyo earthquakes, in which the EW component greatly predominates. For the first 2.3 sec., the vibrations were comparatively small and principally in the NS component :—

(NS) $T = 1.04$ sec., Max. $2a = 9.5$ mm.

(EW) $T = 0.17$ „, Max. $2a = 1.3$ „ (ripples).

Then the motion became much larger, there being 4 displacements (marked, in Fig. 2, respectively *cd*, *de*, *ef*, and *fg*) composing 2 vibrations as follows :—

1st displacement....	{	11.3 mm toward N, 4.5 mm toward W ;
	{	Resultant $2a = 12.3$ mm, toward N22°W.
2nd „	{	16.3 mm toward S, 5.3 mm toward E ;
	{	Resultant $2a = 17.0$ mm, toward S18°E.
3rd (Max.) „	{	22.0 mm toward N, 7.7 mm toward W ;
	{	Resultant $2a = 23.3$ mm, toward N19°W.
4th „	{	9.3 mm toward S, 7.3 mm toward E ;
	{	Resultant $2a = 11.8$ mm, toward S38°E.

The above 4 displacements, together lasting 2.0 sec., constituted the most active part of the earthquake ; the 2nd and 3rd displacements forming the maximum vibration of $2a = 23.3$ mm, and period = **0.95** sec., whose maximum acceleration was 510 mm per sec. per sec. As the mean direction of motion was N24°W–S24°E, these movements took place approximately parallel to the line joining the earthquake origin with the observing place and are due probably to the longitudinal wave. The subsequent motion was smaller, but continued active for about 1m 12s, the period being as follows :—

$$\left. \begin{array}{l} \text{(NS) } T = 0.79 \text{ sec.} \\ \text{(EW) } T = 0.81 \text{ ,,} \end{array} \right\} \text{average, } \mathbf{0.80} \text{ sec.}$$

Vertical Motion.

Preliminary tremor. The motion was very small.

Principal portion. The motion which was small during the first 3.5 sec., was active during the next 18 sec., and consisted of the following vibrations:— $T = 0.47$ sec., Max. $2a = 1.3$ mm.

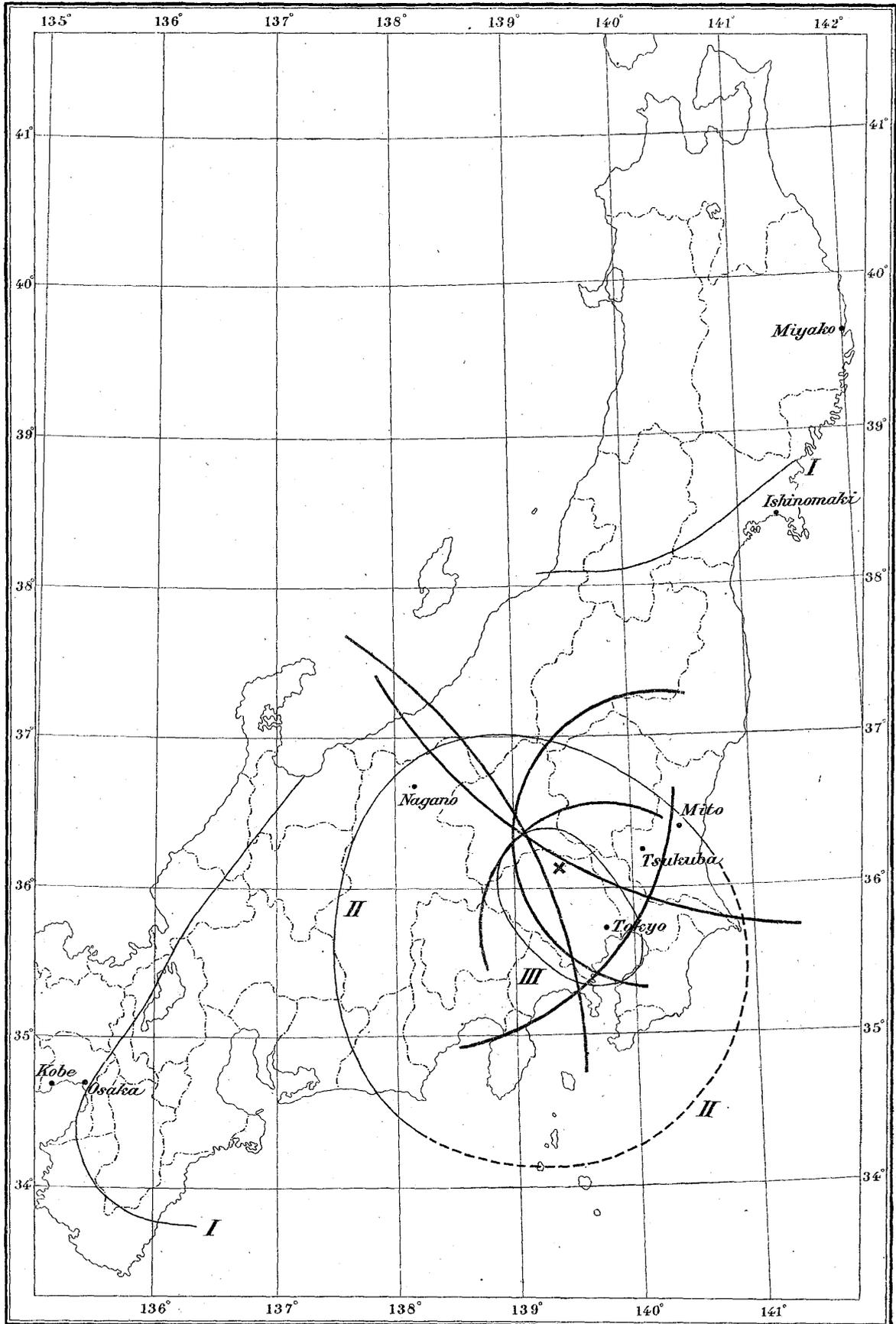
Observation at Hongo (Tokyo). The maximum macro-seismic motion at Hongo was $2a = 10.4$ mm, $T = 0.7$ sec., nearly in the NS direction.

Fig. 1. Tokyo Earthquake of Nov. 22, 1907.

I, II and III are respectively the boundaries of the areas of slight, moderate, and strong movements.

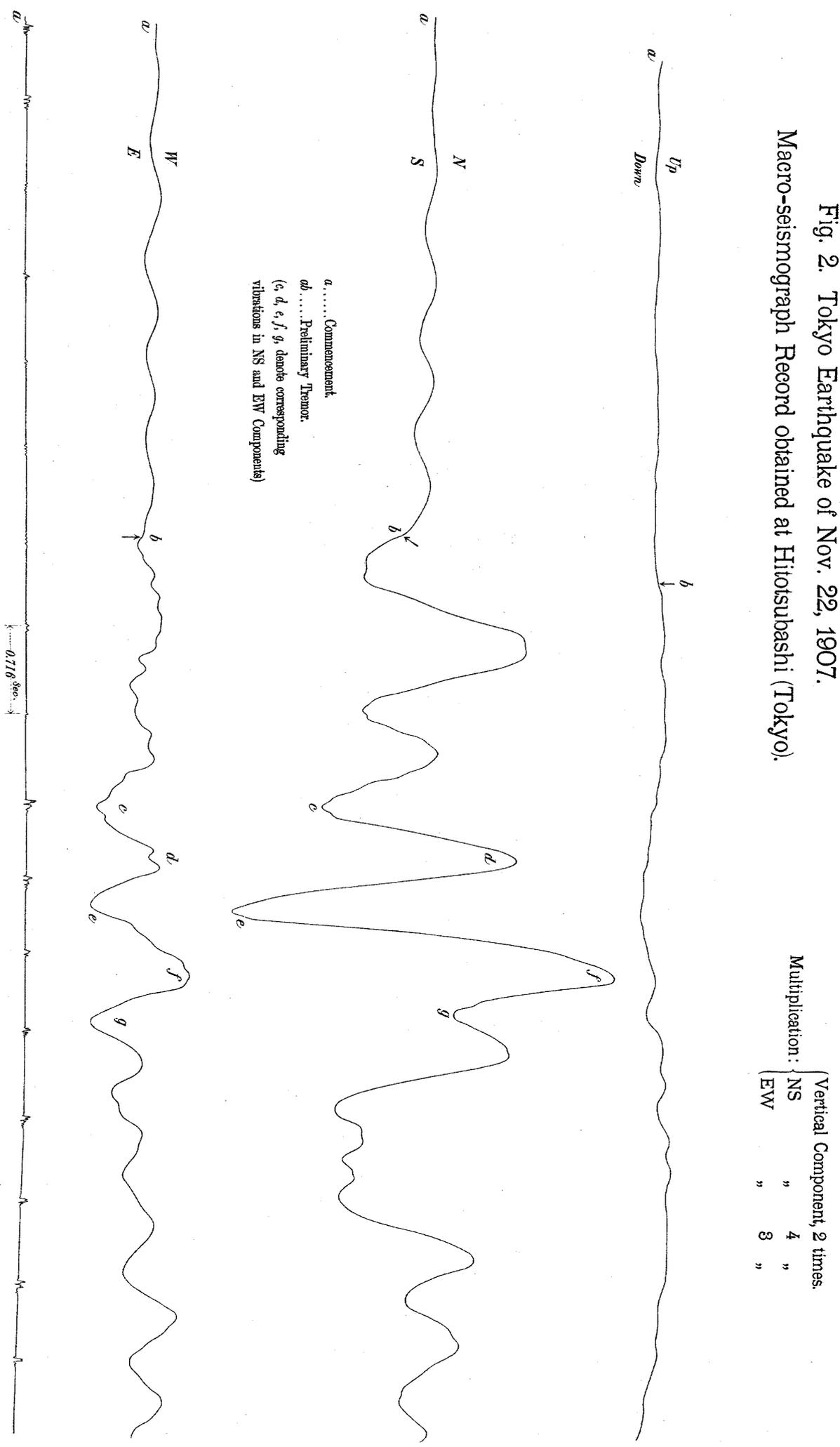
Arcs in red are drawn about the different places as centres with radii calculated from the duration of the preliminary tremor.

(x).....Probable Position of the Earthquake Origin.



----- Boundary of provinces

Fig. 2. Tokyo Earthquake of Nov. 22, 1907.
 Macro-seismograph Record obtained at Hitotsubashi (Tokyo).



Omori Horizontal Pendulum Diagrams of the Tokyo Earthquake of Nov. 22, 1907.

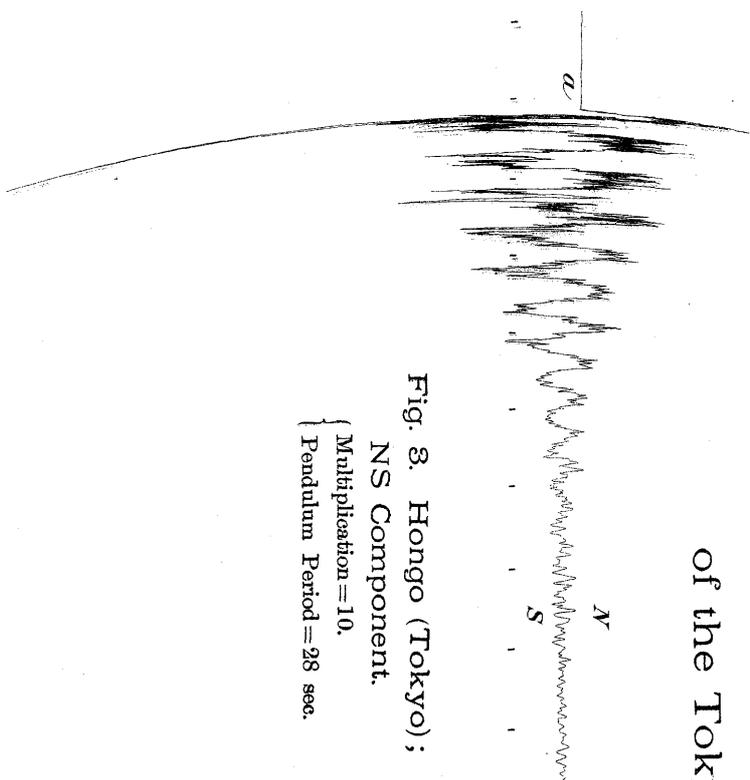


Fig. 3. Hongo (Tokyo);
NS Component.
{ Multiplication = 10.
Pendulum Period = 28 sec.

Time : 1 interval = 1 min.
(a)..... Commencement.

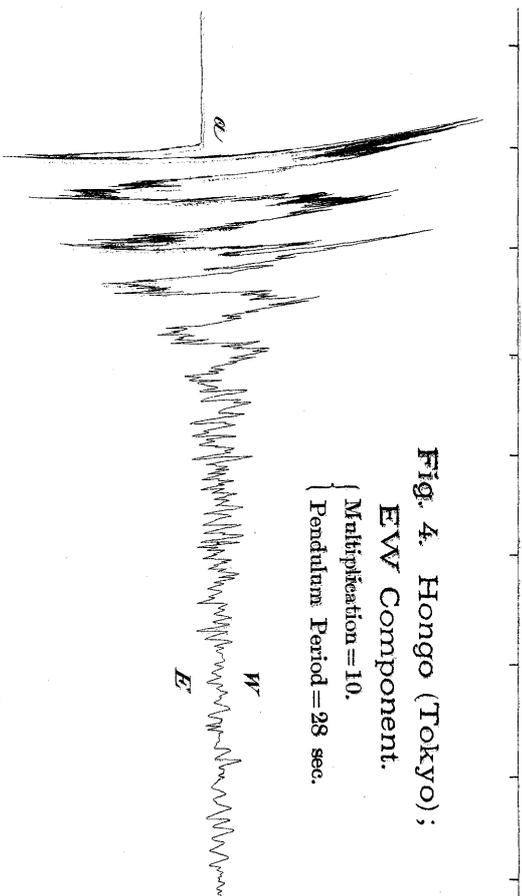


Fig. 4. Hongo (Tokyo);
EW Component.
{ Multiplication = 10.
Pendulum Period = 28 sec.

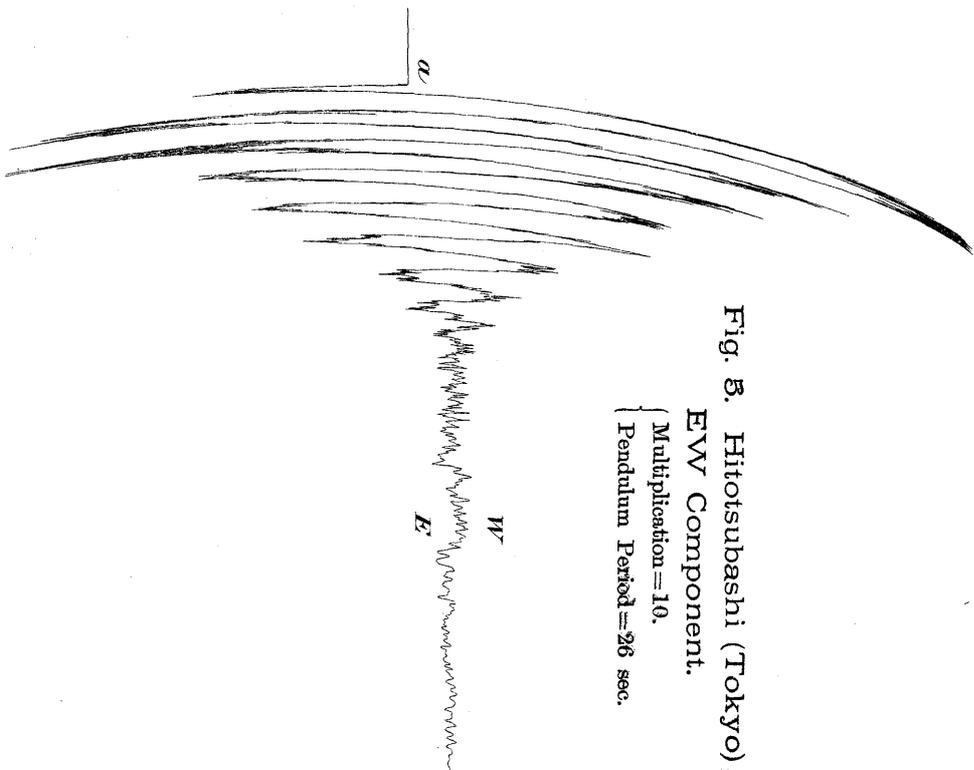


Fig. 5. Hitotsubashi (Tokyo);
EW Component.
{ Multiplication = 10.
Pendulum Period = 26 sec.