The Calabrian Earthquake of Sept. 8, 1905, observed in Tokyo.

By

F. Omori, Sc. D.,

Member of the Imperial Earthquake Investigation Committee.

1. Pl. XV gives the EW, NS, and vertical components of motion due to the disastrous Calabrian earthquake of Sept. 8, 1905, observed in the University compound, (Hongo), Tokyo; the magnifying ratios in the three diagrams being respectively 15, 20, and 12. The details of construction of the two horizontal component instruments,* which are nearly alike to one another, are as follows:—

Vertical distance between the points of suspension and of support=2 metres.

Effective length of the strut, or the horizontal distance between the point of support and the steady axis=1 metre.

Weight of the heavy bob=..... {17.4 kg. (EW). 46.0 kg. (NS).

Natural Oscillation Period ..... {61.5 sec. (EW). 48.5 sec. (NS).

The vertical instrument, which is one of Gray-Ewing type, has the following specifications :

Length of the vertical spiral springs=1.2 metre.

Horizontal distance between the centre of the steady mass and the pivot=1.2 metre.

Weight of the heavy bob=9 kg.

Natural Oscillation period=6.0 sec.

The time of commencement of the earthquake motion was $1^h\ 56^m\ 09^s$ (G.M.T.). In the following descriptions of the seismograms, T and $2a$ denote respectively the complete period and the double amplitude of motion.

* These are the long-period horizontal pendulums described in the *Publications*, No. 5, with some changes in the weight of the steady mass and the multiplication ratios.

2. *EW Component.* Total duration=3 hours. The commencement was very small, and slightly uncertain.

1st Preliminary Tremor. Duration=10^m 25^s. For the first 2^m 0^s, the motion was very small. The subsequent motion was larger and nearly uniform:—T=7.7 sec., max. $2a$=3.3 mm, there being also traces of small vibrations.

2nd Preliminary Tremor. Duration=11^m 49^s. The motion was greater during the first 6^m 20^s than during the rest of this phase:—

$$\begin{cases} T= 6.4 \text{ sec., max. } 2a=0.1 \text{ mm.} \\ \quad 8.3 \text{ ,, , small.} \\ \quad 11.6 \text{ ,, , ,,} \end{cases}$$

Principal Portion. [1st and 2nd phases.] Duration=10^m 43^s. During the first 5^m 48^s, the motion was small:—T=21.2 sec., max. $2a$=0.6 mm., there being also small vibrations of T=8.7 and 6.4 sec. For the next 2^m 25^s, there were 3 small slow vibrations:—T=48.3 sec., max. $2a$=0.05 mm, superposed by small vibrations of T=8.5 sec. For the remaining 2^m 29^s, there were 4 larger and nearly equal vibrations:—T=37.3 sec., max. $2a$=0.13 mm; there being also some small vibrations. [3rd phase.] Duration=9^m 39^s. During the first 2^m 8^s, the motion consisted of $4\frac{1}{2}$ regular vibrations:—T=28.5 sec., the 4th having the max. $2a$ of 0.35 mm. For the next 2^m 38^s, the vibrations were smaller and quicker:—T=21.1 sec., max. $2a$=0.24 mm. For the remaining 4^m 57^s, the vibrations became again quicker:—T=14.5 sec., the two max. $2a$'s of 0.45 and 0.50 mm. occurring respectively 5^m 39^s and 8^m 54^s after the commencement of this phase. There were also some traces of vibrations of T=28.8 sec. [4th phase]. During the first 5^m 25^s, the motion was large:—T=17.7 sec., max. $2a$=0.21 mm; T=11.8 sec., max. $2a$=0.20 mm. During the remaining 10^m 53^s of this phase, the motion was

smaller and nearly uniform:—T=11.1 sec., max. $2a$=0.12 mm; T=16.9 sec., max. $2a$=0.08 mm. [5th, etc. phases]. The motion was much smaller. Toward the end, T=13.9 sec.

The W_2 vibrations, or the earthquake movements propagated along the major arc of the earth, appeared at $3^h\ 47^m\ 10^s$ (G.M.T.)

3. *NS Component.* The commencement was very small and slightly indistinct.

1st Preliminary Tremor. Duration=about $10^m\ 57^s$. For the first 1^m, the motion was very small. The subsequent motion was nearly uniform :—T=6.0 sec., max. $2a$=0.03 mm, mixed with some vibrations of T=11.3 sec.

2nd Preliminary Tremor. Duration=$9^m\ 44^s$. The motion was greater near the commencement :—T=7.0 sec., max $2a$=0.08 mm; T=10.3 sec., max. $2a$=0.12 mm.

Principal Portion. [1st and 2nd phase.] Duration=$11^m\ 30^s$. During the first $9^m\ 44^s$, the motion was nearly constant:—

T=14.9 sec., max. $2a$=0.06 mm;
,,= 8.0 , ,, =0.05 ,, ;
,,= 4.0 , small.

During the remaining $1^m\ 47^s$, there were 2 and half well-defined vibrations:—T=42.8 sec., max. $2a$=0.1 mm. [3rd phase.] Duration=$15^m\ 18^s$. During the first $1^m\ 29^s$, there were 2 and half well-defined and nearly equal vibrations:—T=35.7 sec., max. $2a$=0.22 mm. For the next $2^m\ 14^s$, the vibrations became quicker:—T=26.8 sec., max. $2a$=0.33 mm. For the next $1^m\ 35^s$, the motion was smaller:—T=19.0 sec., max. $2a$=0.25 mm. For the next $1^m\ 11^s$, there were 2 slow small vibrations:—period=35.5 sec., max. $2a$=0.09 mm, superposed with small movements of T=10.1 sec. Thereafter the motion became much quicker and active, the vibrations during the next $2^m\ 31^s$ being T=15.1 sec.,

max. $2a=0.35$ mm, mixed with slower vibrations of T=30.2 sec., max. $2a=0.40$ mm. For the next 1^m 42^s:—T=25.5 sec, max. $2a=0.33$ mm. For the next 1^m 51^s, the motion became again quicker:—T=13.9 sec., max. $2a=0.13$ mm. During the remaining 9^m 28^s, the period remained nearly constant:—T=16.2 sec., max. $2a=0.43$ mm, mixed with some small vibrations of T=10.3 sec. [4th, etc. phases.] During the first 8^m 20^s:—T=11.3 sec., max. $2a=0.08$ mm; T=19.7 sec., max. $2a=0.09$ mm.

End Portion. The vibrations had a T of 13.2 sec., there being also some vibrations of T=17.1 sec.

The W_2 vibrations which appeared at 4^h 06^m 26^s (G.M.T.), were small but well defined:—T=18.5 sec., max. $2a$=small.

4. *Vertical Component.* The motion began with small quick vibrations. At 2^h 32^m 57^s (G.M.T.), there appeared small slow vibrations continuing for about 10 min. 7^m 20^s later on the movements became more distinct:—T=15.2 sec., max. $2a=0.03$ mm.

Appendix. The observations of the Calabrian earthquake at Osaka and Mizusawa were as follows:—

Osaka (*EW*).

Total Duration=1^h 24^m. Time of commencement=1^h 56^m 31^s.

1st Prel. Trem. Duration=10^m15^s; T=6.6 sec.; max. $2a=0.2$ mm.

2nd „ „ „ =11 10; „=6.7 „; „ „ =0.7 „

Principal Portion:—

1st and 2nd phases.	Dur.=7^m10^s;	T=20.0 sec.;	max. $2a=0.4$ mm.
3rd phase.	„ =8 25; „ =21.9 „;	„	=0.5 „
4th „	„ =8 30; „ =17.1 „;	„	=0.4 „
5th „	„ =9 00; „ =12.7 „;	„	=0.1 „
6th „	„ =8 10; „ =15.4 „;	„	=0.5 „

7th phase. Dur.=7 45 ; T=13.8 sec.; max. $2a$=0.2 mm.

End Portion. „ =14.4 „ ; „

Mizusawa.

Time of commencement=1^h 56^m 12^s.

Max. $2a$=0.03 mm. (EW Component),
„ =0.09 „ (NS „).

The instruments at Osaka and Mizusawa are h[illegible]ntal pendulums of portable form, the natural oscillation [illegible]od at Osaka being about 28 sec.

Earthquake of Calabria (Italy). Sept. 8, 1905.: 1h 56m 09s. G. M. T.

Observed at Hongo, Tokyo.