CHAPTER X. OBSERVATION OF THE STRONG OZASA EARTHQUAKE OF FEB. 22ND, 1916.

92. ***Ozasa earthquake.*** The earthquake on Feb. 22nd, 1916, which caused some damage at the village of Ozasa and the vicinity at the N. base of the Asama-yama, was much greater than the proper volcanic earthquakes originating at the latter (§§ 85 and 86). Amongst the others the motion was satisfactorily recorded by the ordinary seismograph at the meteorological observatory of Nagano, 36 km. distant from the epicentre. In the following §§ I describe the seismograms obtained at Nagano, Ueda, and Maebashi.

93. ***Ordinary seismograph record at Nagano.*** The machine was an ordinary Gray-Milne type seismograph with three rectangular components, which was started automatically by the earthquake shock and whose instrumental constants were as follows:—

Time of one revolution of the recording drum = 90 sec.
Length of the smoked paper = 947 mm.
Magnification of each horizontal component pointer = 5.
„ the vertical „ = 10.

The strong earthquake has occurred while the fore-shock had not ended and while the recording drum of the seismograph was still revolving. The preliminary tremor, which lasted 4.4 sec., began with a slow oscillation whose first movement was as follows:—

Horizontal motion = 0.40 mm., directed toward S. 49° E.
Downward motion = 0.53 mm.

The periods of the quick vibrations mixed with the slow oscillations were:—horiz. compt., 0.079 sec; vert. compt., 0.23 sec. (and still shorter ones). At the end of the preliminary tremor, there

took place a conspicuous slow oscillation of T=1.5 sec., as follows:—

1st Displacement.	2nd Displacement.
3.14 mm., toward S. 31° E.	2.42 mm., toward N. 25° W.
1.0 mm., upwards.	1.45 mm., downwards.

In the principal portion, the motion was small for the first 2.0 sec., the first oscillation being composed as follows:—

1st Displacement.....2.76 mm., toward S. 34° E.
2nd „ .....4.36 mm., toward N.35° W.

At 6.4 sec. from the earthquake commencement the motion became most active, being composed of the following 6 successive displacements:—

1st Displacement,	....13.3	mm.,	toward	S. 64° E.	} These 2 make up a vibration of T=1.76 sec.
2nd „	....15.3	„	„	N.57° W.	
3rd „	....15.0	„	„	S. 51° E.	} These 4 together make up a slow vibration of T=3.4 sec.
4th „	....17.6	„	„	N.35° W.	
5th „	....21.6	„	„	S. 24° E.	
6th „	....25.8	„	„	N.11° W.	

These displacements were essentially longitudinal in nature, although their directions gradually changed.

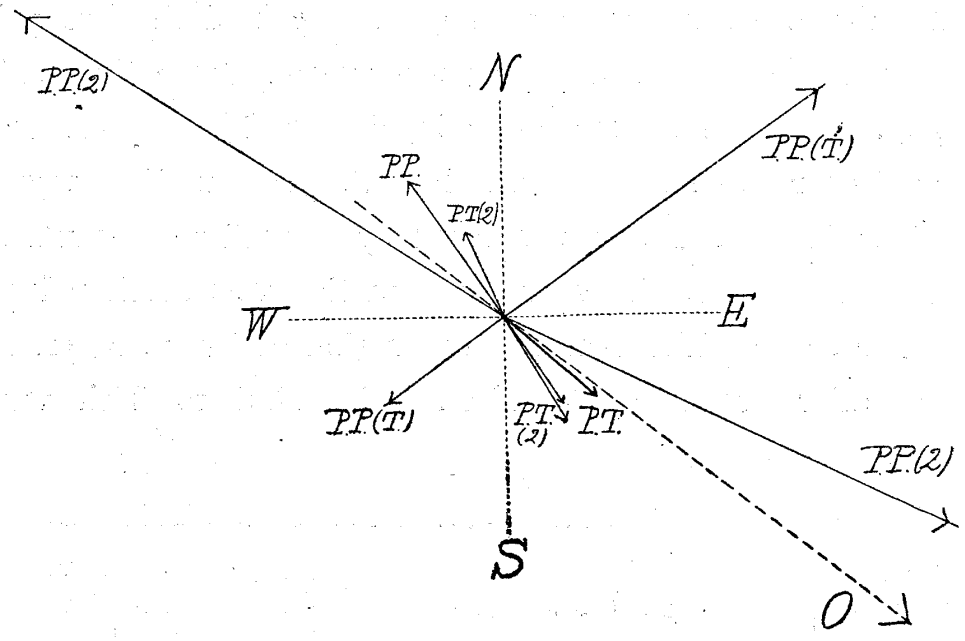
Simultaneously with the commencement of the 3rd displacement there took place a large vertical vibration of 2a=3.8 mm., T=1.47 sec.

The motion in all the three components was reduced practically to zero at 21.5 sec. after the earthquake commencement, when took place a 2nd series of smaller but well-defined vibrations which lasted 6.8 sec. in the horizontal and 9.3 sec. in the vertical direction. The different successive displacements were as follows:—

1st	Displacement,	.... 4.0 mm.,	toward	S. $60\frac{1}{2}°$ W.		
2nd	„	....10.5 „	„	N.55° E.	}	These together make up an oscillation of T=2.2 sec.
3rd	„	.... 9.6 „	„	S. 59° W.		
4th	„	.... 7.6 „	„	N.70° E.		
5th	„	.... 8.8 „	„	S. 80° W.		
6th	„	.... 6.8 „	„	N.76° E.		

These displacements belong to the transverse wave. The corresponding vertical vibrations had a period of T=1.54 sec. The subsequent motion was much smaller.

Fig. 43. Diagram showing the Directions of Motion in the Different Portions of the Nagano Seismograms of the Strong Ozasa Earthquake on Feb. 22nd, 1916.



P.T.....Preliminary Tremor (earlier part).
P.T.(2) .... „ „ (later part).
P.P.....Principal Portion (earlier part).
P.P.(2) .... „ „ (later „).
P.P.(T) .... „ „ (Transverse Wave).
0 .....Earthquake Origin.

94. *Tromometer registers at Nagano meteorological observatory.* The following account is based on the diagrams furnished

by a tremor-recorder with two horizontal components, of 75 times magnification and of the proper pendulum period of 4 sec.

The fore-shock, which had occurred 85 sec. previous to the main earthquake and whose preliminary tremor lasted 4.7 sec., began with the first displacement of 0.007 mm. directed toward the S.E. The principal portion was as follows:—

E.W. Compt.....Max. $2a=0.18$ mm., Duration=22 sec.
N.S. „ ..... „ $=0.15$ „ „ $=22$ „

The main earthquake, whose total duration was 21 minutes began with a large distinct displacement of 1.52 mm. directed toward the S. 55° E., corresponding to a semi-period of 3.4 sec. The counter displacement was very large and caused the two pointers to run out of the smoked paper; the movements in the E.W. and the N.S. components being respectively over 2.3 mm. (toward the W.) and over 2.0 mm. (toward the N.). The motion was most active for 105 sec. and was followed by a smaller maximum group for the next 90 sec. Thereafter the motion was much reduced.

After-shocks. The elements of motion of the more prominent of the after-shocks registered on Feb. 22nd to 24th were as follows:

Duration of Preliminary Tremor.	1st Displacement.	Max. 2a.	
		E.W. Compt.	N.S. Compt.
4.7 sec.	0.070 mm. toward S. 62° E.	1.01 mm.	0.80 mm.
4.7	——	0.047	——
—	0.099 S. 54° E.	1.98	1.01
3.5	——	0.57	0.28
4.7	——	0.06	0.048

Duration of Preliminary Tremor.	1st Displacement.	Max. 2a.	
		E.W. Compt.	N.S. Compt.
4.7	0.057 mm. toward S. 55° E.	0.84 mm.	0.64 mm.
4.1	——	0.093	0.051
4.3	——	0.022	0.037
6.7	0.049 S. 29° E.	1.20	0.73
4.7	(2nd slow motion=0.051 mm. toward N. 49° W.)	0.96	0.82
4.5	0.0078 S. 40° E.	0.69	0.72
4.0	——	0.08	0.045
5.0	——	——	0.021
4.5	——	——	0.013
4.4	——	0.11	0.047

95. ***Summary of Nagano observations.*** The results relating to the direction of motion may be summarized as follows. (See fig. 43.)

The initial displacement, averaged from the fore-shock, the main earthquake, and 6 of the after-shocks, was directed toward the S. 50° E.

Preliminary tremor. The vibrations in the preliminary tremor were of the nature of the longitudinal wave, the direction of the first and the last displacements of this epoch being as follows:—

Initial Displacement.....S. 49° E.
End „ .....S. 28° E.

Preliminary portion. The well-defined displacement at the beginning of the principal portion, which occurred 6.4 sec. after the earthquake commencement, was directed toward the S. 35° E. The two first displacements (2a = 15.3 mm.) of the maximum and

longitudinal group, which occurred 2.0 sec. later on, had the average direction of S. 60° E. and N. 60° W. The two first displacements (2a=10.5 mm.) of the secondary and transverse group, which occurred 21 sec. after the earthquake commencement, had the average direction of S. 58° W. and N. 58° E.

96. *Observation at Ueda sericultural college.* (150 times magnification E.W. component horizontal pendulum tromometer.) The preliminary tremor of the fore-shock, whose duration was 2.2 sec., began with the first displacement of 0.0037 mm. toward W.; the max. 2a=0.013 mm. The principal portion began with the following 3 successive displacements: 0.047 mm. toward W., 0.37 mm. toward E., and 0.61 mm. toward W. Thereafter the motion rapidly decreased.

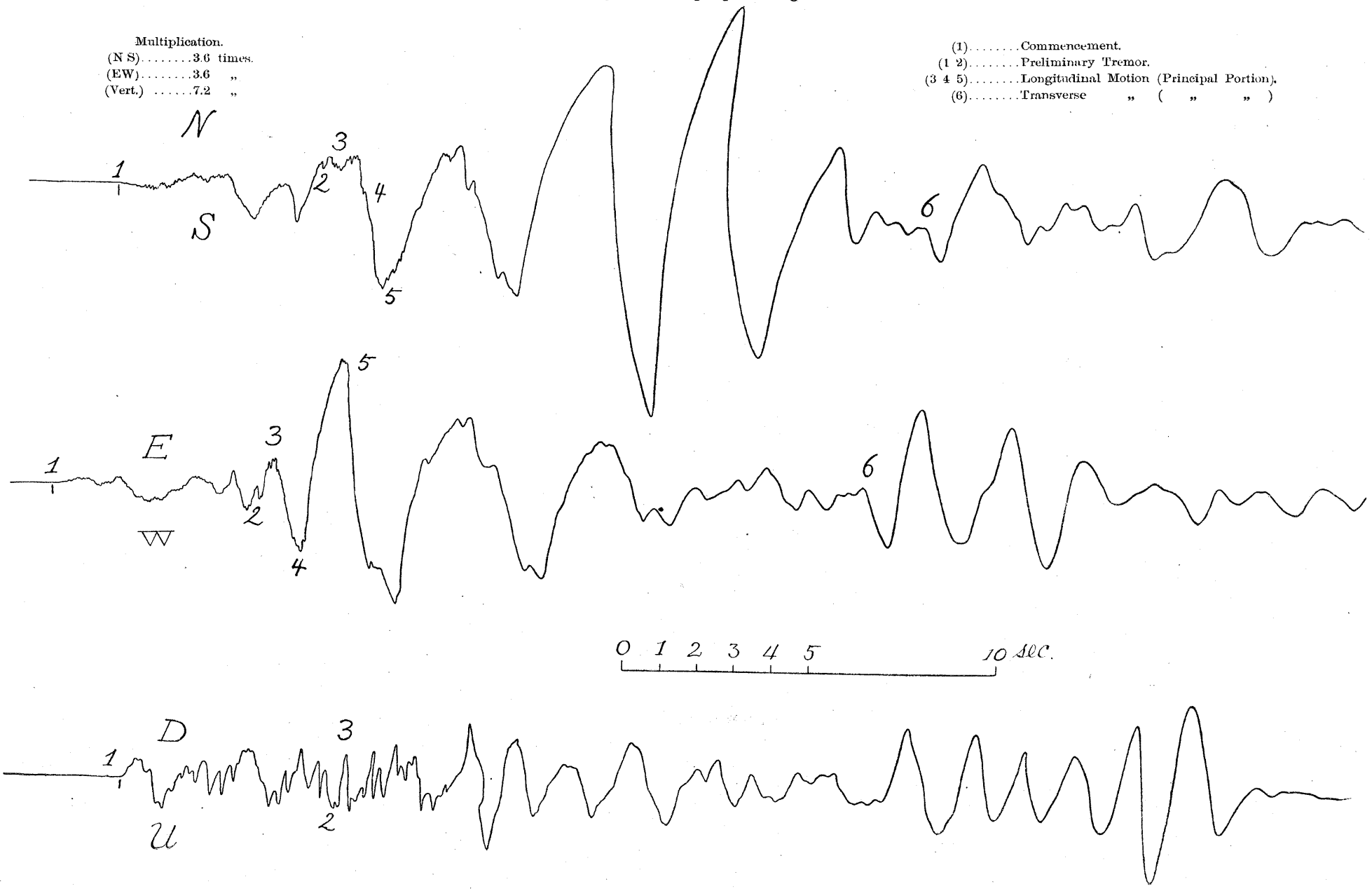
The main shock began with the following two displacements: a=0.043 mm. toward W., and 2a=0.21 mm. toward E. The 3rd displacement was greater than 0.9 mm. and the instrument pointer went out of the recording smoked paper.

97. *Observation at Maebashi meteorological observatory.* The duration of the preliminary tremor of the fore-shock was 5.6 sec., and that of the 8 prominent among the after-shocks on Feb. 22nd to 24th was as follows :—

6.0 sec.	
6.9	
6.0	
6.5	
5.9	mean=6.1 sec.
5.8	
6.1	
5.9	

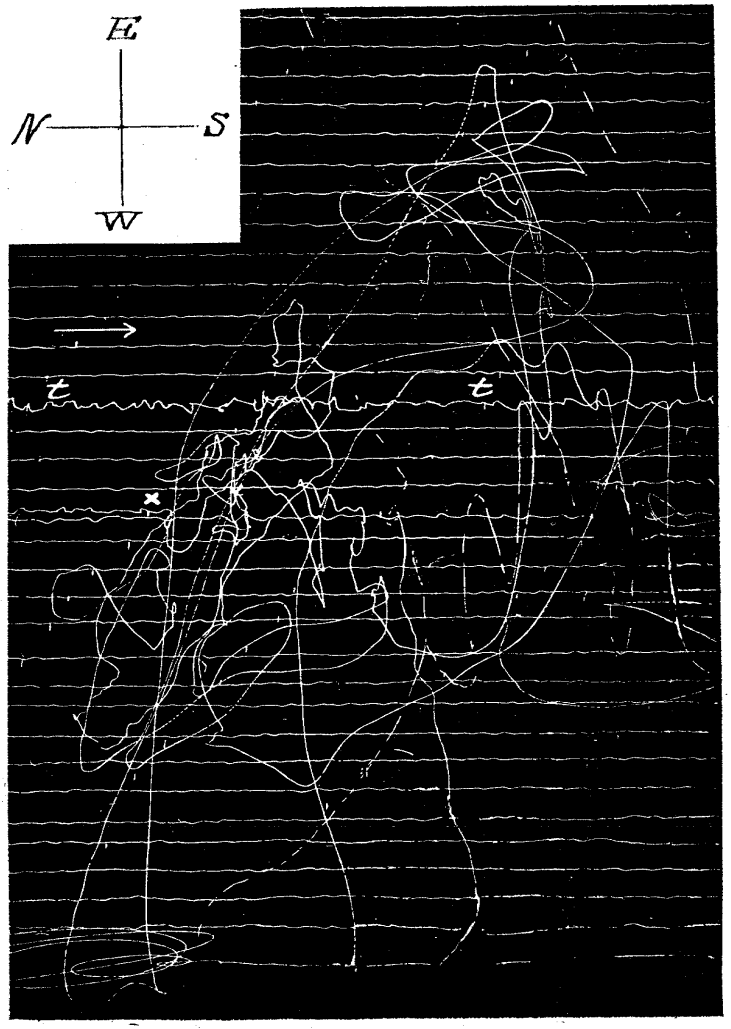
Fig. 44. Strong Ozasa Earthquake of Feb. 22, 1916, observed at the Meteorological Observatory of Nagano.

Ordinary Seismograph Diagram.



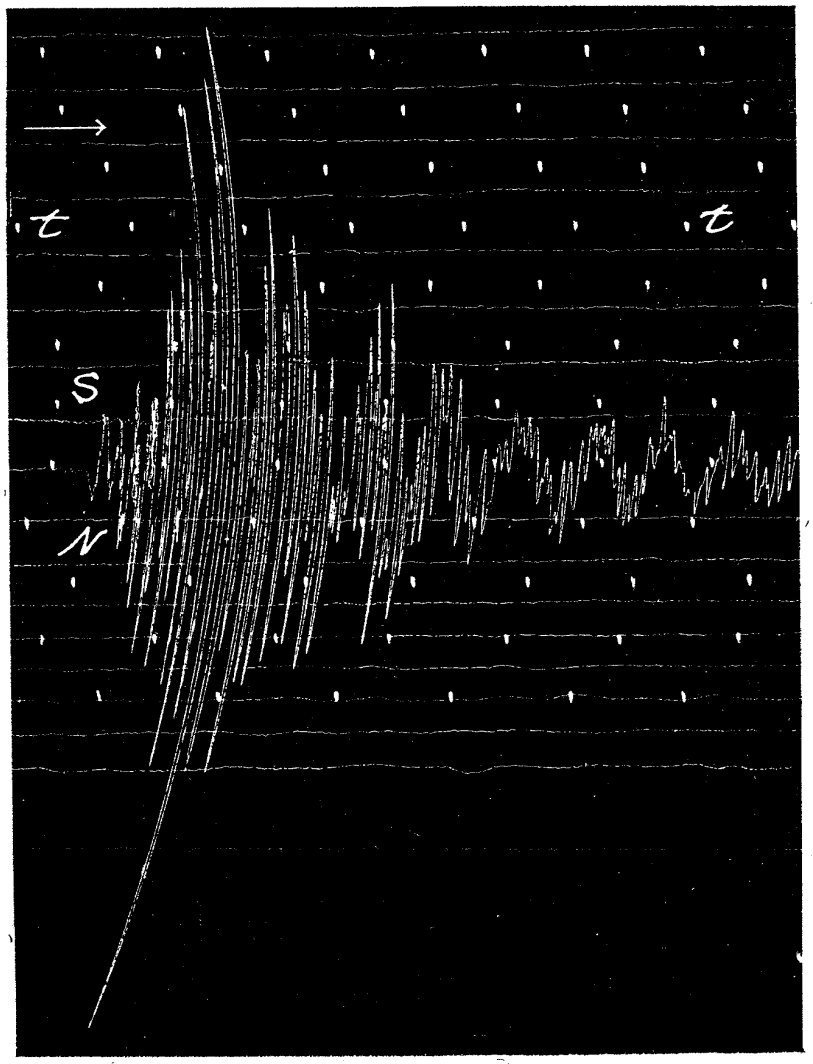
Tokyo Observation of the Strong Ozasa Earthquake on Feb. 22nd, 1916.

Fig. 45. Pantograph Record.
(Magnification = 20.)



t....Time (Minute) Mark.

Fig. 46. N.S. Hor. Pendulum Record.
(Magnification = 20.)



Tokyo Observation of the Strong Ozasa Earthquake on Feb. 22nd, 1916.

t.....Time (Minute) Marks.

Fig. 47. E.W. Component Motion.

(Magnification = 10.)

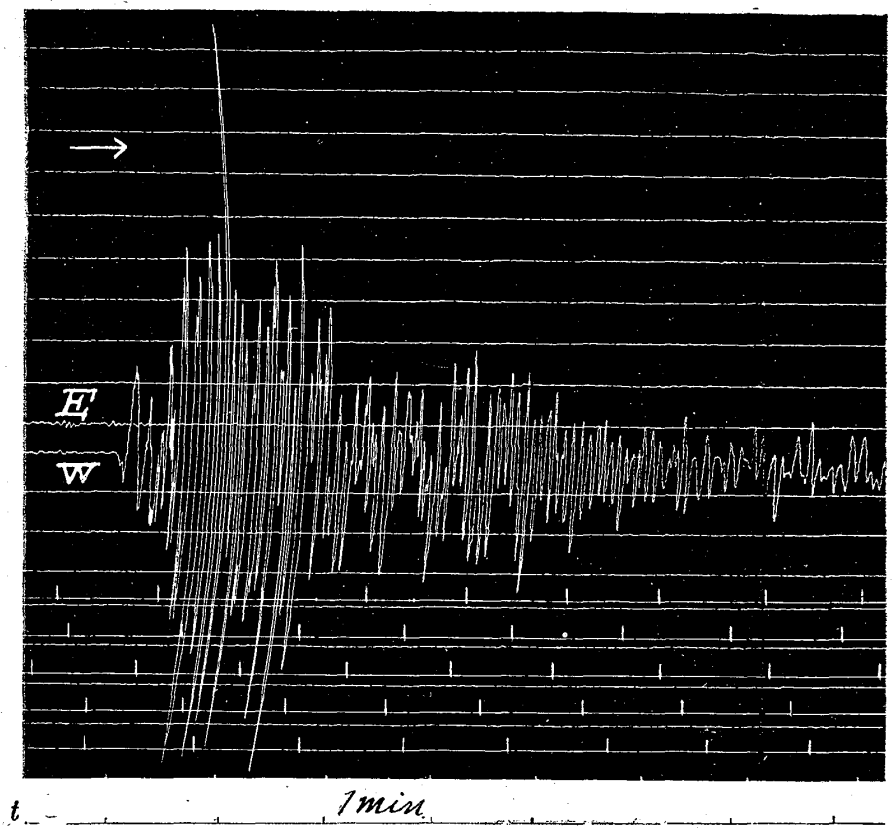
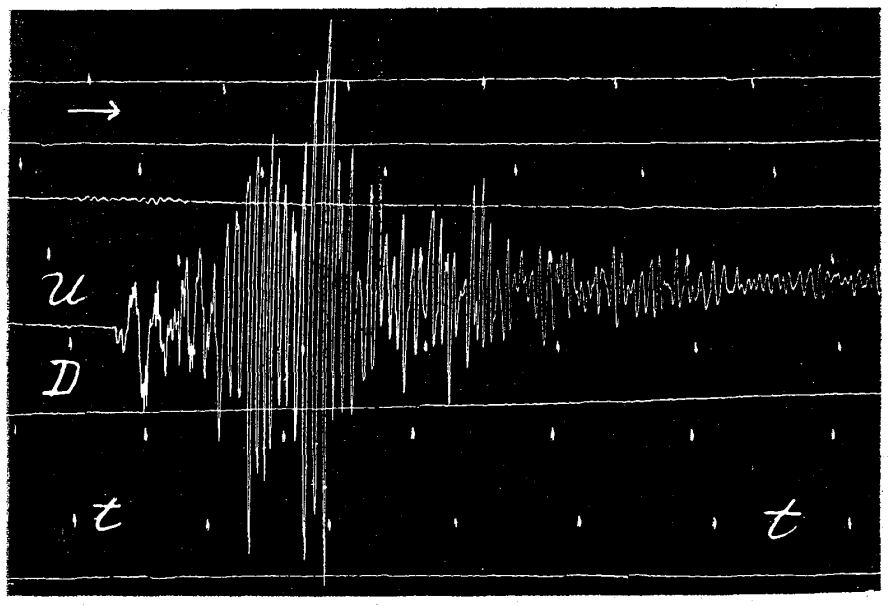


Fig. 48. Vertical Component Motion.

(Magnification = 12.)



Tokyo Observation of the Prominent After-shocks of the Strong Ozasa Earthquake of 1916.

Pantograph Record. (Magnification = 35.)

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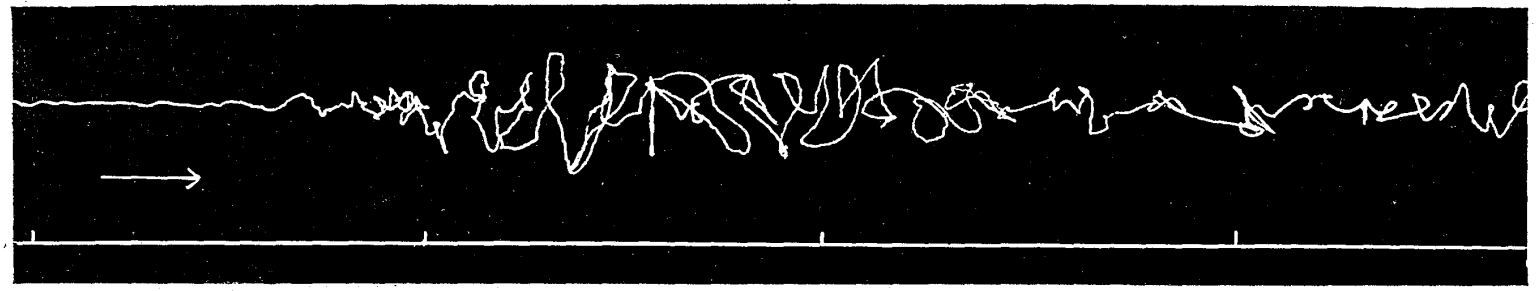

Fig. 49.
Feb. 22nd, 1916,
8.30.36 p.m.

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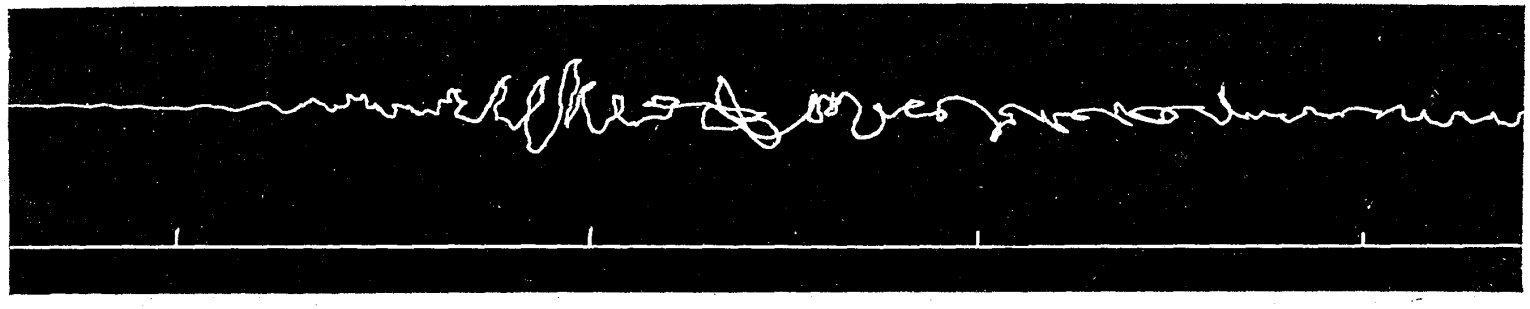

Fig. 50.
Feb. 23rd, 1916,
3.03.08 a.m.

*

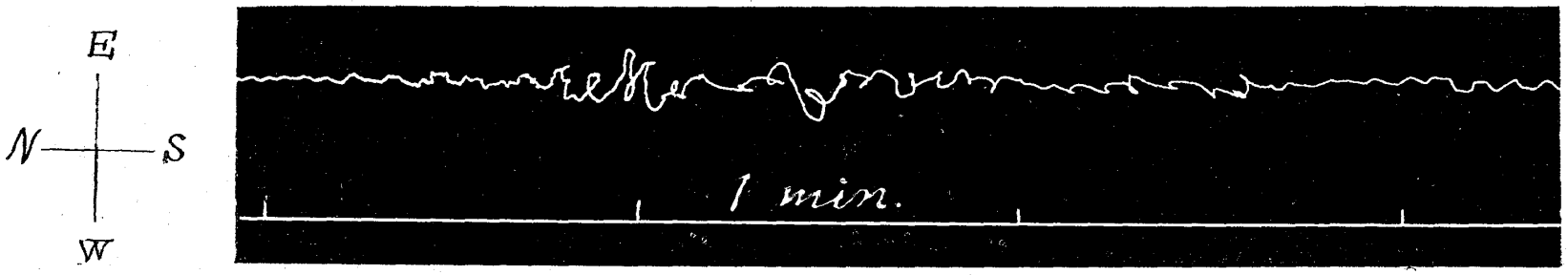

Fig. 51.
Feb. 23rd, 1916,
3.08.12 a.m.

(* Commencement of the Transverse Wave.)

Tokyo Observation of After-shocks of the Strong Ozasa Earthquake on Feb. 22nd, 1916.

(E.W. Component Motion.)

Fig. 52. Earthquake on Feb. 22nd, 1916, at 8.41.05 P.M.

(1)....Magnification=12. (2)....Magnification=18.

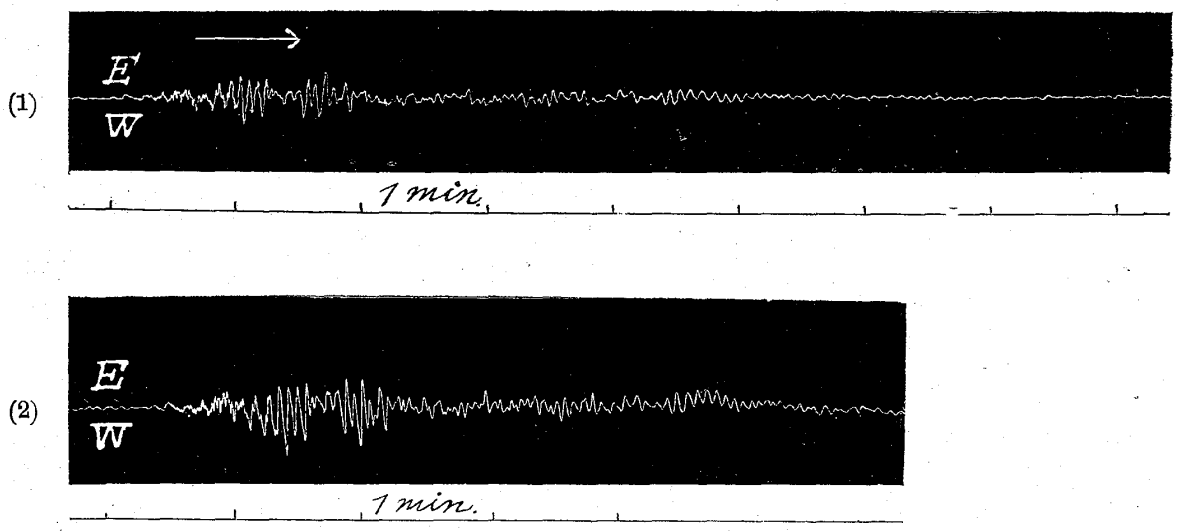

Fig. 53. Earthquake on Feb. 23rd, 1916, at 3.03.08 A.M.

(1)....Magnification=12. (2)....Magnification=18.