

Horizontal Pendulum Observations of Earthquakes,
July 1898 to Dec. 1899, Tokyo.*

GROUP I.—*Distant Earthquakes.*

Eqke No. 2. July 15th, 1898; 1898; 2h 6m 14s a.m.

Total duration=1h 4m.

(NS component).

The 1st P.T., whose duration was 6m 40s, began very gradually and consisted essentially of regular vibrations of an average period of 4,9s, not superposed on slower undulations. The max. 2a was 0,02 mm. It may be added that there existed no P.O., so that the commencement of the earthquake was quite sharply defined.

The 2nd P.T., whose duration was 7m 35s, was characterized by the appearance of slower and larger undulations. During the first 3m the waves were regular and had an average period of 9,5s. For the next 1m, the amplitude was small and the average period was 3,1s. Later on waves of an average period of 8,1s predominated. A maximum motion of 0,1 mm occurred at 2m 6s from the commencement of the 2nd P.T., movements slightly larger than this also occurring towards the end of this epoch.

The P.P. began with well defined regular undulations which lasted for 2m 53s, and whose average period was 10,8s, the max. 2a of 0,55 mm occurring at 2h 2m 27s. Then followed an interval of rest, which comprised six small waves of an average period of 8,1s. The 2nd

* The time is given in the First Normal Japan Time, namely, that of longitude 135° E.

maximum epoch began at 2h 30m 14s and lasted for 2m; the average period being 11,6s, and a maximum 2a of 0,45 mm occurring at 11m 3s from the start. This was followed again by an interval of rest, which lasted for 36s, and consisted of small waves of an average period of 7,2s. The 3rd maximum epoch began at 2h 32m 55s and consisted of waves of an average period of 9,2s, the maximum 2a being 0,35 mm. So far may be regarded as the P.P., which thus lasted for 7m 54s.

The E.P. consisted of regular undulations, with occasional slight maxima. The average period, deduced from five successive groups of 50 vibrations, was as follows:—

8,6s (at the commencement)	}	(General mean) 8,9s.
9,2		
8,8		
9,3		
8,5 (towards the end)		

In the P.P. and the E.P. the diagram shows a series of maximum movements, whose times of occurrence, counted from the commencement of the P.P., are as follows:—

m s	m s
0.34	21.32
1.57	22.18
5.03	23.56
6.25	25.16
7.47	26.23
9.37	27.29
12.02	29.29
13.22	31.25
14.41	32.01
16.32	32.48
17.20	33.55
19.29	35.05
20.13	36.03

m s	m s
37.11	44.14
38.45	45.55
40.30	47.21
41.39	

(EW component).

The 1st P.T., whose duration was 8m 2s, began gradually with small vibrations of an average period of 5,0s. The max. 2a was 0,02 mm.

The 2nd P.T., whose duration was 6m 53s, had an average period of 8,7s, there being also some slight traces of slower undulations. The max. 2a was 0,13 mm.

The P.P. The max. 2a of 0,35 mm. occurred at 2h 10m 48s. The average period deduced from six successive groups of 50 vibrations, was as follows :—

9,0s (at the commencement)	}	(General mean)
7,9		
8,9		
9,4		
9,8		
9,0 (towards the end)			9,0s.

In the P.P. and the E.P. the diagram showed a series of alternations of more or less distinct max. and min. epochs. The times of occurrence of the successive maximum movements, counted from the commencement of the P.P. were as follows :—

m s	m s
0.37	7.57
2. 7	9.20
3.46	11.18
4.43	12.35
5.53	13.57
7.27	15.57

m s	m s
17.14	23.20
18.27	24.11
19. 7	25. 0
19.54	25.39
20.27	26.42
21.40	27.48
22.24	etc., etc.

Eqke No. 11. August 8th 1898; 4h 57m 35s p.m.

Total duration = 1h 20m.

This was a large earthquake at a great distance.

(NS component).

The P.T., whose duration was 7m 7s, began very gradually with vibrations of an average period of 4,2s, superposed on slower undulations of an average period of 9,3s.

The P.P. lasted 17m and consisted essentially of two series of waves whose average periods were respectively 16s and 10,2s. The max. 2a of 0,5 mm (period = 13,2s) occurred at 5h 17m 55s, and a second max. 2a of 0,35 mm (period = 13,6s) at 5h 23m 23s.

The E.P. The average period was 11,1s.

(EW component).

The P.T., whose duration was 6m 44s, consisted of small but well defined vibrations of an average period of 7,4s.

The P.P. began with 9 slow undulations which occupied 3m 12s and had an average period of 21,2s, the largest 2a being 0,25 mm. During the next 3m 5s the motion remained small and had a shorter average period of 13,5s. The followed the most active groups of vibrations, whose max. (abs.) 2a was 0,35 mm, and average period 10,8s.

The E.P. The average period was 9,8s.

Eqke No. 22. September 1st 1898; 5h 0m 57s a.m.

Total duration = 1h 45m.

This was a large earthquake at a great distance.

(NS component).

The 1st P.T. lasted for 8m 40s. During the first 1m 40s the motion was very small (max. $2a=0,05$ mm), the average period being 4,8s. During the remaining 7m, the amplitude which was larger (max. $2a=0,2$ mm) remained nearly constant; the motion consisting of vibrations of an average period of 7,2s superposed on traces of others of average periods of 13,4s and 3,9s.

The 2nd P.T. lasted 4m 34s. The amplitude remained nearly constant (max. $2a=0,45$ mm) and the principal average period was 13,9s. Towards the end there were some slow undulations of an average period of 24,3s.

The P.P., lasted 13m 20s. The motion was especially large during the first 7m 30s, which comprised three separate groups of vibrations, the second one having the greatest $2a$ of 8,1 mm. In each of these groups the motion gradually reached a maximum, probably on account of the synchronism of the pendulum with the shakings of the ground, the average period being 16,6s. In the remaining portion of this epoch, the average period was 12,8s.

The E.P. The average period deduced from four successive groups of 50 vibrations, taken at the commencement, was as follows:—

9,9s (at the commencement)	}	(General mean)
11,5		
11,9		
11,5 (near the end)		
		11,2s.

(EW component).

The 1st P.T. lasted 8m 45s. During the first 1m 37s the motion was very small, the average period being about 5s. During the remaining 7m 7s, the motion which was larger (max. $2a=0,25$ mm) remained nearly constant or rather greater in the earlier than in the later part. The average period was 7,7s.

The 2nd P.T. lasted for 4m 47s. The max. $2a$ was 0,4 mm and the

principal average period 14,5s. Towards the end there were traces of slow undulations of an average period of 25s.

The P.P. lasted for 9m 45s, the motion being particularly active for the first 5m. It began with four slow undulations, which lasted for 1m 49s and had an average period of 27,3s; the second wave having the max. 2a of 3,0 mm. The following five waves had a quicker average period of 16,8s and lasted for 1m 24s; the third one having the max. 2a of 3,2 mm. Then the vibrations became still quicker and had an average period of 11,3s; the second one having the max. 2a of 2,6 mm.

The E.P. The average period, measured at the commencement, was 10,4s.

Eqke No. 23. September 1st 1898; 6h 2m 17s p.m.

Total duration = 50m.

(NS component).

The P.T. lasted for 3m 14s, the motion being rather greater in the earlier and middle parts than in the end. The max. 2a was 0,35 mm and the principal average period 8,5s. There were also traces of small vibrations of an average period of 4,2s.

The P.P., whose duration was 12m 54s, began with two well pronounced waves of an average period of 15s, the first of which had a max. 2a of 1,2 mm. After 1m, there appeared quicker vibrations (max. 2a = 0,5 mm) which lasted for 1m 41s and had an average period of 4,8s. The subsequent motion consisted of quicker waves superposed on slower ones.

The E.P. The waves had an average period of 10,1s, being here and there superposed with smaller vibrations which were probably P.O.

(EW component).

The commencement was somewhat confused by the superposition of several lines. The P.T. lasted for about 3m 15s, its max. 2a being 0,24 mm.

The P.P. began with two well defined vibrations (max. 2a = 1,1 mm) whose average period was about 21s. These were followed by quicker ones, whose average period was 9,6s.

P.O. There existed slight P.O., whose average period was 5,3s.

The following observations at Naha and seven other Meteorological Observatories probably refer to the same earthquake:—

Naha	..	..	..	5h 57m 50s	p.m.	..	..	..	Slight.
Oshima	..	..	..	6. 0. 5		..	..	..	Weak.
Ishigakijima	..	..	..	6. 3. 11		..	..	..	Strong.
Tokyo	..	..	..	6. 2. 19		..	..	..	Slight.
Kumagae	..	..	..	6. 2. 20		..	..	..	„
Mito	..	..	..	6. 2. 24		..	..	..	„
Taihoku	..	..	..	5. 58. 50		..	..	..	Weak.
Taichu	..	..	..	5. 46. 0		..	..	..	Slight.

Eqke No. 24. September 4th 1898; 0h 26m 49s a.m.

Total duration = 36m.

(NS component).

The P.T., whose duration was 7m 40s, consisted essentially of vibrations of an average period of 9,6s, superposed with small ones of an average period of 4,2s. These latter were probably P.O.

The P.P., whose duration was 7m 47s, consisted of undulations of an average period of 14,5s; the introductory movement having the max. 2a of 0,15 mm. The amplitude remained nearly constant during the first 4m 45s.

The E.P. consisted of quicker vibrations whose average period was 9,5s.

(EW component).

The P.P., whose duration was 7m 52s, consisted during the first 2m 12s of slow vibrations of an average period of about 13,2s. The succeeding waves had essentially an average period of 9,5s. The max. 2a was 0,1 mm.

P.O. There existed slight quick P.O., whose average period, measured 1h before the earthquake, was 3,9s.

Eqke No. 29. September 14th 1898; 3h 2m 10s a.m.

Total duration = 1h.

The beginning is perfectly well defined, the initial motion being 0,09 mm towards S.

The 1st P.T., whose duration was 8m 26s, consisted essentially of small well defined quick vibrations of an average period of 5,7s. Traces of waves of longer period did not exist. The motion was maximum at the commencement, becoming smaller towards the end.

The 2nd P.T., whose duration was 10m 26s, was characterized by a sudden increase in the amplitude and by the appearance of slower undulations, whose average period was 24,6s and whose max. $2a$ of 0,2 mm (first motion was directed towards S) occurred at the beginning; the motion becoming, as in the 1st P.T., smaller towards the end. These undulations were superposed with quicker vibrations which formed a continuation of those in the 1st P.T., (average period being 6,9s) and which ceased almost completely towards the end of this epoch.

The P.P. is characterized by the appearance of a series of regular slow undulations, free from superpositions, and lasted for 10m 34s, the motion being most active for an interval of 5m 37s from 1m 28s after the commencement. The first 5 waves were small and had an average period of 19s. Then followed seven large well defined undulations of an average period of 25s, the (absolute) max. $2a$ of 0,3 mm occurring at 3h 14m 27s a.m. These were followed by eight smaller (max. $2a=0,15$ mm) and nearly equal vibrations of an average period of 22s. The motion then temporarily subsided, becoming again larger towards the end; these concluding vibrations having an average period of 19s.

In the E.P. again appeared traces of the small vibrations of an average period of 4,7s.; these being superposed on slower undulations, which were, however, probably the proper oscillations of the pendulum, as the average period was 17s.

The EW component diagram was somewhat obscured by the superposition of several lines. The max. $2a$ in this direction was 0,2 mm.

Eqke No. 33. September 22nd 1898; 9h 26m 11s p.m.

Total duration = 3h.

This was evidently a large earthquake at a considerable distance.
(EW component).

The 1st P.T., whose duration was 5m 37s, began very gradually with small movements of an average period of 3,4s. After about 2m 15s, the motion became more pronounced, consisting of waves of an average period of 9,2s, superposed with others of an average period of 5,4s. The max. 2a during this epoch was 0,12 mm and occurred towards the end of the latter.

The 2nd P.T., whose duration was 4m 18s, began with a displacement of 0,28 mm and consisted of undulations of an average period of 13,6s, superposed by small vibrations of an average period of 5,4s.

The P.P., whose duration was 18m 30s, was well defined and began with a displacement of 1,25 mm and of period 16,2s. The vibrations in the most active portion, which lasted for 6m 25s, had an average period of 14,3s; these being grouped more or less definitely into slower undulations of an average period of 28s, i.e. proper oscillations of the pendulum. The (abs.) max. 2a of 1,9 mm occurred at 3m 17s and also at 5m 8s from the commencement of the P.P., their period being 22s. In the part immediately following the most active epoch, the waves had an average period of 13,3s, interposed or superposed by smaller waves of an average period of 8,5s.

The E.P. consisted, for the first 6m 48s, of waves of an average period of 16,4s, superposed with smaller vibrations of an average period of 8,8s. After this, the slow period undulations disappeared, and the motion consisted entirely of vibrations of the same kind as above mentioned, the average period deduced from ten successive groups of 50 vibrations being as follows:—

9,1s	}	(General mean 9,6s.
9,2		
9,9		
9,6		
9,0		
9,6		
9,2		
9,6		
10,0		
10,3		

(NS component).

The max. 2a of 1,9 mm occurred at 5m 8s from the commencement of the P.P.

Eqke No. 35. September 25th 1898; 9h 22m 46s p.m.

Total duration = about 30m.

This was an earthquake at a great distance and began very gradually. The time interval between the commencement of the earthquake (which was not quite sharply defined) and the beginning of the P.P. was 10m 50s.

The earlier part of the P.P. consisted of slow waves of an average period of 20s, superposed with small vibrations of an average period of 8,2s. The max. 2a was 0,05 mm in the EW and 0,04 mm in the NS component.

In the E.P., the average period was 10,4s.

Eqke No. 40. October 1st 1898; 1h 29m 12s a.m.

Total duration = about 4m.

This was a small earthquake at some distance, the motion being very small.

Eqke No. 43. October 10th 1898; 7h 35m 39s a.m.

Total duration = 48m.

The P.T. was not definitely recorded, having been probably lost on account of the smallness of motion.

This was a small earthquake at a great distance.

The average period in the P.P. was 22s.

Towards the end, the average period was 14s.

Eqke No. 44. October 12th 1898; 1h 45m 38s a.m.

Total duration = $2\frac{1}{2}$ h.

This was evidently a large earthquake at a great distance. Traces of slow undulations continued to be seen more or less definitely for $4\frac{1}{4}$ hours after the time interval given above as the total duration of the shock. As there was no P.O. before the earthquake this shows that the ground remained for several hours in a disturbed state. The 1st and 2nd P.T. and the P.P. were all well defined, the very initial motion being 0,1 mm towards N and 0,08 mm towards E. (NS component).

The 1st P.T., whose duration was 6m 3s, consisted essentially of waves of an average period of 9,1s, superposed with smaller vibrations of an average period of 4,5s ($2a = 0,1$ mm). The max. $2a$ of 0,2 mm occurred at the commencement, the motion lessening towards the end of this epoch. Traces of vibrations of longer period did not exist.

The 2nd P.T. whose duration was about $2\frac{1}{2}$ m, was marked by an abrupt increase in the amplitude and consisted essentially of vibrations of an average period of 7s, superposed on slow undulations of an average period of about 15s; the max. $2a$ of 0,25 mm being the first motion of this epoch, directed towards S.

The P.P., whose duration was 6m 26s, began at 1h 53m 57s a.m. with ill defined traces of slow undulations of an average period of 37,5s, superposed with other irregular vibrations of an average period of 21s. Besides these, small vibrations of an average period of 7,5s continued to exist till 1h 58m 1s a.m., i.e. 12m 32s after the commencement of the earthquake, when the (abs.) max. $2a$ of 0,75 mm took place followed by seven large well defined waves of nearly an equal amplitude. These 8 waves, toge-

ther occupying a time interval of 2m 52s, formed the most conspicuous part of the motion and had an average period of 21,5s. The succeeding movements, whose average period was 19,7s, were again superposed with small vibrations of an average period of 7,4s.

The E.P. consisted essentially of waves, whose average period deduced from ten successive groups of 50 vibrations was as follows:—

8,4s (at the commencement)	}	
8,4		
8,7		
10,4		
9,0		
9,5		(General mean)
9,7		9,3s.
8,6		
10,0		
9,8 (near the end)		

During the first 16m of this epoch, there were also some slight traces of undulations of an average period of 18s. Near the end, slight maxima occurred at nearly regular intervals.

(EW component).

The 1st P.T., whose duration was 5m 57s, consisted of vibrations of an average period of 7,6s, superposed here and there with traces of very small vibrations of an average period of 1,7s; long-period undulations did not exist. The max. 2a was 0,2 mm.

The 2nd P.T., whose duration was 3m 43s, began with an abrupt motion of 0,5 mm towards E, and consisted of 12 slow undulations of an average period of 18,6s; these being again superposed with small waves of an average period of 7,4s. Slight traces of slow waves of an average period of 37s seemed also to exist. The amplitude decreased towards the end of the epoch.

The P.P., whose duration was about 15m, began with 10 well defined slow undulations of an average period of 25s, whose max. 2a of 0,8 mm

occurred at 1h 56m 43s; these waves being superposed with small vibrations of an average period of 7,2s. The latter then almost disappeared and there appeared 9 well defined, waves of an average period of 21s; of these the first was the maximum, having a range of 0,45 mm. In the remaining portion of this epoch the motion was much smaller.

The E.P. The average period, measured at about $\frac{3}{4}$ h from the beginning of the earthquake, was 8,6s.

Eqke No. 45. October 19th 1898; 4h 27m 48s a.m.

Total duration = 39m.

This was a small earthquake at some distance, the motion consisting of regular vibrations free from superpositions, chiefly in the NS component.

The P.T. lasted for about 8m 26s.

The P.P. In the earlier portion of this epoch, the average period was 11s; later on it was 19s. The max. 2a was 0,7 mm in the NS and very small in the EW component.

Eqke No. 47. October 22nd 1898; 9h 2m 42s a.m.

Total duration = 1h 7m.

(EW component).

The P.T. lasted 9m 12s and consisted of small but well defined vibrations of an average period of 7,6s, the amplitude remaining nearly constant.

The P.P., whose duration was 9m, began with small slow undulations (max. 2a = 0,15 mm) which lasted 4m 39s and had an average period of 31s, superposed with small quicker vibrations of an average period of 8,9s. Then followed the most active group of waves, whose average period was 20s, and whose first displacement had the max. 2a of 0,3 mm.

The E.P. The average period was as follows:—

10,9s (at the commencement);

16,5 (towards the end).

(NS component).

The P.T., whose duration was 10m 32s, consisted of vibrations of an average period of 8,1s; the amplitude remaining nearly constant.

The P.P. lasted about 7m. For the first 4m 26s the motion was slow (max. $2a=0,14$ mm), the average period being 27s. Then followed quicker vibrations of an average period of 17,5s, the first of the group having the max. $2a$ of 0,15 mm.

Eqke No. 48. October 22nd 1898; 10h 35m 53s p.m.

Total duration = 20m.

The commencement was not well defined, but the P.T. lasted for about 1m 43s and consisted of waves of an average period of 2,7s, superposed more or less distinctly on slow undulations of an average period of 12s.

The P.P. lasted for 4m 30s. During the first 1m 26s, the average period was 7,8s, the max. $2a$ being 0,08 mm in the EW and 0,05 mm in the NS component. Later on the waves had an average period of 7,4s, superposed with small vibrations of an average period of 3,8s.

The E.P. The average period was 5,6s, the waves being regular.

Eqke No. 50. November 2nd 1898; 8h 43m 15s p.m.

Total duration = about 17m.

The motion was very slight and began gradually.

The P.T. lasted for about 6m (?) and had an average period of 6,7s.

The P.P. The average period was 7,6s, and the max. $2a$ was 0,04 mm in each component.

Eqke No. 51. November 5th 1898; 8h 48m 45s p.m.

Total duration = about 15m.

This was a small earthquake at a great distance, the motion being very small.

The P.T. was not well defined.

In the P.P., the average period was 18s.

Eqke No. 57. November 14th 1898; 4h 5m 23s p.m.

Total duration=40m.

This was a small earthquake at some distance.

The P.T., whose duration was 1m 28s, consisted of very small vibrations of an average period of 5,9s, superposed with traces of quicker ones of an average period of about 2,3s.

The P.P., whose duration was 7m, consisted, during the first 3m 29s, of very small vibrations superposed on waves of an average period of 5,2s. Then took place the max. 2a of 0,24 mm in the EW and 0,19 mm in the NS component, followed by well defined vibrations whose average period, deduced from four successive groups of 50 vibrations, was as follows:—

7,1s	}	(General mean)
7,8		
8,7		
8,6		
		8,1s.

P.O. There existed slight traces of P.O., whose average period was 5,6s.

Eqke No. 58. November 17th 1898; 9h 54m 53s p.m.

Total duration=2h 30m.

This was a large earthquake at a distance.

(EW component).

The P.T., whose duration was 4m 8s, consisted of vibrations of an average period of 8,4s, superposed with some traces of smaller ones of an average period of 5,6s. The max. 2a was 0,12 mm.

The P.P., whose duration was 11m 30s, began with 6 slow undulations which lasted 2m 32s and had an average period of 25,4s, the first vibration having the largest 2a of 1,0 mm. So far may probably be taken as the 2nd P.T., and the motion was superposed with small vibrations of an average period of 6,9s. Then followed the most active part of the motion, which lasted 4m 40s and comprised three nearly equal maximum groups of vibrations with two minimum groups between them; the max. 2a

being 1,6 mm. During the first 2m 10s of this latter epoch the average period was 21,7s, and during the remaining 2m 30s it was 15,2s. The following vibrations had an average period of 13,4s.

The E.P. There were alternations of slight maximum and minimum groups of vibrations. The average period deduced from seven successive groups of 50 vibrations, taken at the commencement of this epoch, was as follows:—

13,0s
13,0
12,0

(After these the period became constant and somewhat quicker).

10,0s	}	(General mean)
11,0		
11,0		
10,0		
		10,5s.

Towards the very end the average period was 11,0s.
(NS component).

Here the 1st and 2nd P.T. may be distinguished.

The 1st P.T., whose duration was 4m 21s, consisted essentially of small vibrations of an average period of 8,4s, superposed with traces of smaller and quicker ones. The max. 2a was 0,12 mm.

The 2nd P.T., whose duration was about 2m, began with the max. 2a of 0,55 mm. The motion consisted of small vibrations of an average period of 7,2s, superposed more or less distinctly on traces of slow undulations of an average period of about 25s.

The P.P., whose duration was 9m 40s, consisted, during the first 4m 28s, of slow undulations grouped into three nearly equal maximum groups, (max. 2a=1,7 mm); the average period being 21,6s. Then followed the most active group of vibrations (max. 2a=3,1 mm), which, however, were probably in a part due to the proper pendulum oscillations, the average period being 16,7s.

The E.P. The average period, deduced from six successive groups of 50 vibrations, taken at about 45m after the commencement of the earthquake, was as follows:—

10,2s	}	(General mean)
10,2		
9,4		
10,9		
11,4		
10,8		
		10,5s.

Eqke No. 61. November 22nd 1898; 8h 20m 3s p.m.

Total duration = 1h 13m.

(NS component).

The beginning of the motion was not well defined. The time interval between the assumed commencement and the appearance of the P.P. was about 6m 30s.

The P.P. The max. 2a was 0,06 mm and the average period in the earlier portion was 12s.

The E.P. The average period was 9,8s.

The EW component diagram was lost on account of the stoppage of the clock-work of the corresponding machine.

Eqke No. 64. November 30th 1898; 7h 31m 18s a.m.

Total duration = 17m.

The beginning of the motion was very gradual but well defined.

The P.T. was not well defined, but the time interval between the beginning and the epoch of the maximum activity of motion was 5m 30s. During this portion, the motion consisted of very small ill defined waves of an average period of about 7,1s, superposed with traces of others still smaller.

The P.P. lasted for about 1½m. The max. 2a was 0,04 mm in each component, and the average period was 7,6s.

Eqke No. 65. Dec. 1st 1898; 9h 53m 53s p.m.

Total duration = 33m.

The beginning was not sharply defined, and the motion increased gradually, reaching the maximum epoch about 6m 20s later on.

The P.P. The average period was 15s, and the max. 2a was 0,06 mm in the EW and 0,02 mm in the NS component, the motion being very small in the latter component.

The E.P. The average period was 12s.

P.O. There were very slight P.O., whose average period was 4,1s.

Eqke No. 69. December 11th 1898; 3h 39m 22s p.m.

Total duration=1h 18m.

This was a large earthquake at a great distance. The commencement of motion was gradual but well defined.

(EW component).

The 1st P.T., whose duration was 9m 58s, consisted of very small and indistinct vibrations of an average period of 6s.

The 2nd P.T., whose duration was 6m 7s, was characterized by the appearance of more pronounced vibrations, whose average period was 7,6s. The max. 2a was 0,02 mm, the amplitude remaining nearly constant or being rather slightly greater at the commencement than at the end.

The P.P. began at 3h 55m 18s with traces of small slow undulations, whose average period was 27,5s, superposed with small vibrations of an average period of 8,0s. From 4h 0m 48s set in regular well defined undulations (max. 2a=0,05 mm), with slight alternations of maxima and minima epochs. Their average period, deduced from four successive groups of 20 waves were as follows:—

17,9s	}	(General mean)
17,9		
17,0		
16,8		
		17,4s.

At about 1h 1m from the commencement of the earthquake there appeared again a slight maximum group, the motion having been almost perfectly nil for the preceding 14m.

(NS component).

The 1st P.T., whose duration was 9m 50s, consisted of very small vibrations of an average period of about 7,3s, these being superposed with traces of vibrations of still quicker period.

The 2nd P.T., whose duration was 12m 12s, consisted of vibrations of an average period of 7,7s. The max. 2a was 0,05 mm, the motion being more pronounced at the commencement than at the end.

The P.P. began with 17 well defined slow undulations, which formed the maximum group (max. 2a=0,06 mm), and whose average period was 23s, occupying together 6m 31s. For the next 5m 20s the motion was small, and the average period was 18,8s. Then followed a second maximum group of 16 undulations (max. 2a=0,05 mm) which together occupied 4m 36s, the average period being 17,2s. After this the motion decreased.

Eqke No. 76. December 30th 1898; 11h 23m 49s p.m.

Total duration=about 13m.

The P.T., whose duration was 32s consisted of very quick small movements.

The P.P., whose duration was 6m 30s, began with a motion of 0,08 mm towards E and also 0,08 mm towards N. For the first 1m, the motion consisted of sharp quick vibrations (max. 2a=0,4 mm in the EW and 0,3 in the NS component) superposed on others whose average period was 2,6s, and whose max. (abs.) 2a of 0,4 mm in the EW and 0,35 mm in the NS component occurred at 1m 2s from the beginning of this epoch. There were also slower waves whose average period was 7,6s and whose max. 2a was 0,34 mm in the EW and 0,3 mm in the NS component. From about 11h 26m 47s there appeared well defined vibrations of an average period of 3,3s, their max. 2a being 0,35 mm in the EW and 0,26 mm in the NS component.

The E.P. Near the end the average period was about 5,8s.

P.O. There was a storm of small and quick P.O., the max. 2a being 0,04 mm in each component. Their average period was as follows:—

4,4s (measured just before the earthquake),

4,3 (" " after " ")

Eqke No. 82. January 23rd 1899; 11h 9m 57s p.m.

Total duration = 27m.

(NS component).

The P.T. whose duration was 6m 45s, consisted of vibrations of an average period of 8,3s, superposed with others still smaller.

The P.P. lasted for 5m 47s, the motion being however comparatively small during the first 1m 38s. The waves, whose max. 2a was 0,13 mm, had an average period of 8,3s, superposed with smaller vibrations of an average period of 3,7s.

The E.P. was more or less active during the first 4m 15s, the average period being 8,0s.

(EW component).

The P.T. lasted for 6m 38s, and the max. 2a was 0,08 mm.

Eqke No. 84. January 27th 1899; 10h 47m 32s p.m.

Total duration = about 7m 20s.

This was a small earthquake at a distance, the motion consisting of regular vibrations.

(EW component).

The P.T., whose duration was 54,5s, consisted of regular small vibrations of an average period of 1,95s, superposed on traces of slower waves of an average period of 6,4s.

The P.P., whose duration was 2m 26s, consisted of well defined vibrations of an average period of 4,7s. The max. 2a was 0,05 mm.

(NS component).

The max. 2a was 0,04 mm.

P.O. There were some slight traces of quick P.O. Their average period, measured about 5h after the earthquake, was 4,1s.

Eqke No 86. February 1st 1899; 2h 52m 43s p.m.

Total duration = 26m.

This was a small earthquake at some distance. The beginning of the motion was somewhat obscured by the existence of slight P.O.

The P.T. lasted for 5m 35s and showed some doubtful traces of slow undulations of an average period of 20s, superposed with the same small vibrations as occurred in the P.P.

The P.P. consisted of vibrations of an average period of 9,2s, the max. 2a being 0,05 mm in each component.

Eqke No. 88. February 11th 1899; 4h 52m 3s p.m.

Total duration=about 27m.

This was a small earthquake at some great distance. The beginning and end of the diagram was confused by the existence of strong P.O.

(NS component).

The duration of the P.T. was doubtful.

The P.P. began from about 1m 13s from the assumed beginning of the earthquake. For the next 22m the amplitude remained very nearly constant, with occasional alternations of max. and min. groups. The max. 2a was 0,07 mm in the EW and 0,08 mm in the NS component.

(EW component).

The motion was small for the first 6m 58s, which probably may be taken as the P.T.; the average period was 5,3s. After this, there appeared traces of slow undulations whose average period was 22s.

P.O. Immediately before the commencement of the earthquake, the average period of the P.O. was 7,8s, the max. 2a being 0,04 mm. Again a little after the earthquake, the average period was 3,9s, the max. 2a being 0,03 mm. A change in the period of P.O., like this, is rather rare.

Eqke No. 93. February 28th, 1899; 11h 48m 55s a.m.

Total duration=1h 30m.

This was a moderately large earthquake at a great distance. The beginning of the diagram was obscured by the presence of slight P.O.

(EW component).

The P.T., whose duration was 7m consisted of vibrations of an average period of 7,3s.

The P.P., whose duration was 23m, had no single prominent maximum motion but consisted of a number of alternations of max. and min. groups. The max. 2a was 0.16 mm in the EW and 0,22 mm in the NS component. (NS component).

The average period in the P.P., deduced from 3 successive groups of 50 vibrations, were as follows:—

$$\left. \begin{array}{l} 9,3s \\ 9,2 \\ 8,9 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 9,1s. \end{array}$$

Eqke No. 95. March 3rd 1899; 9h 50m 2s a.m.

Total duration=about 20m.

This was a small earthquake at a distance. The beginning and end of the diagram was confused by P.O.

(NS component).

The motion began very gradually. The P.P. whose duration was about 5m 15s set in at about 5m 30s from the assumed commencement of the earthquake, the average period being 15,8s. The max. 2a was 0,03 mm.

(EW component).

The max. 2a=0,05 mm.

The P.O. had an average period of 4,5s, its max. 2a being 0,03 mm in each component.

Eqke No. 97. March 6th 1899; 11h 36m 8s p.m.

Total duration=about 25m.

This was a small earthquake at some distance.

(NS component).

The exact beginning as well as the end of the motion was somewhat obscure on account of the presence of P.O.

The P.T. lasted for about 5m 28s.

The P.P. consisted of a group of vibrations of an average period of 7,9s, followed by alternations of very slight max. and min. epochs.

P.O. The average period, measured about 1h after the commencement of the earthquake, was 7,7s.

(The EW component diagram was obscured by the superposition of lines.)

Eqke No. 98. March 7th 1899; 4h 39m 50s a.m.

Total duration=about 1h.

This was a moderately large earthquake at some distance.

The commencement of the motion was obscured by P.O., but the time interval between the assumed beginning and the occurrence of the max. 2a (=0,06 mm in each component) was 22m 20s. The P.P., whose duration was about 18m, consisted of vibrations of an average period of 8,7s.

The E.P. The average period, measured about 1½h after the commencement of the earthquake, was 8,0s.

Eqke No. 102. March 15th; 6h 9m 14s a.m.

Total duration=21m.

This was a small earthquake at some distance.

The commencement of the motion was obscured by the presence of small and quick-period P.O.

(EW component).

The P.T. was not well defined. During the first 2m 25s the average period was 12,1s. Then the motion became slightly quicker, the average period in the next 4m being 7,7s. The group of the most active movements occurred at about 7¼m from the commencement of the earthquake, the max. 2a being 0,05 mm. What may be regarded as the P.P. lasted for about 7m 20s.

(NS component).

The max. 2a was 0,15 mm.

P.O. The average period, measured 1h after the earthquake, was 3,8s.

Eqke No. 107. March 21st 1899; 11h 35m 44s p.m.

Total duration=44m.

This was evidently a moderate earthquake at some great distance.

(EW component)

The P.T. was not definitely shown, but its duration may be taken at about 4m 13s. For the first 26s, the motion was small; then a displacement of 0,2 mm took place, and thereafter the amplitude remained nearly constant for 3m 47s, the average period being 7,8s.

The P.P., whose duration was 9m 46s, consisted of vibrations of an average period of 8,3s, superposed at first on slow undulations of an average period of 25,4s. The max. 2a of 0,36 mm occurred at 11h 41m 48s.

The E.P. The average period, deduced from three successive groups of 50 vibrations, was as follows:—

8,0s	}	(General mean)
8,2		
8,5		
		8,2s.

(NS component).

For the first 34s the motion was small, then took place a motion of 0,28 mm, the amplitude remaining nearly constant for the next 4m 2s. After this the motion became larger.

Eqke No. 110. March 23rd 1899; 8h 30m 59s p.m.

Total duration=about 23m.

The P.T. The commencement was somewhat obscure but the time interval between the assumed beginning and the occurrence of the maximum group was 6m 8s.

The P.P. consisted of traces of very slow undulations of an average period of 23,5s.

Eqke No. 111. March 23rd 1899; 9h 23m 14s p.m.

Total duration=28m.

This was a small earthquake at some distance and the motion began very gradually.

The P.T. was not well defined, but its duration may be taken to be about 10m 30s. The average period was 4,3s.

The P.P. had an average period of 7,4s, the maximum motion (0,03 mm in the NS and 0,05 mm in the EW) occurring near its commencement. From about 9h 30m 35s there appeared some traces of slow undulations of an average period of 20s.

Eqke No. 113. March 24th 1899; 0h 29m 5s a.m.

The diagram merely shows a trace of a distant small earthquake.

Eqke No. 126. April 16th 1899; 11h 1m 34s p.m.

Total duration = about 1h 5m.

This was a small earthquake at a great distance. The commencement was somewhat obscure, the motion being too small.
(NS component).

The P.T. lasted for 17m 10s and consisted of traces of vibrations of an average period of 8,4s.

The P.P., whose duration was 26m, began gradually with traces of slow undulations. After 4m 20s there appeared regular well defined vibrations, whose average period was 8,7s, and whose max. 2a was 0,1 mm in the EW and 0,05 mm in the NS component. This max. 2a was not prominent, but there were a great number of alternations of nearly similar max. and min. groups; the maxima occurring at an average interval of 1,2m.

The motion ceased almost completely at 0h 15½m p.m.; but a new slight trace of disturbance again occurred at 0h 48½m p.m., with an average period of 8,5s.

(EW component).

The P.T. lasted for 17m 59s.

The P.P. The average period of the vibrations was 9,2s. The groups of maximum amplitude occurred at an average interval of 1,6m, the greatest group occurring at 9¼m from the commencement.

Eqke No. 127. April 17th 1899; 10h 46m 50s a.m.

Total duration=1h 57m.

This was a large earthquake at a great distance.

As there was no P.O. before the earthquake, the commencement of the latter was perfectly clear; The 1st and 2nd P.T. as well as the P.P. were also well defined.

(EW component).

The 1st P.T., whose duration was 9m 0s, began very gradually. After 1½m, however, the motion increased, the max. 2a being 0,04 mm. The average period was 7,2s.

The 2nd P.T., whose duration was 10m 8s, was characterized by an increase in the amplitude, which remained sensibly constant throughout this epoch or rather slightly decreasing towards the end. The max. 2a was 0,07 mm, and the average period was 7,8s. There were also some traces of slow undulations.

The P.P., whose duration was 29m 26s, began with a group of well defined (abs. max.) slow undulations of nearly an equal amplitude, which together occupied 7m 43s and had an average period of 20s. Of these, the first 8 vibrations were particularly slow and had an average period of 26s, the max. 2a being 0,14 mm. Superposed on these slow undulations there were smaller waves of an average period of 11,9s. The motion for the next 5m 5s consisted of well defined quick regular undulations, whose max. 2a was 0,05 mm and whose average period was 9,2s. The motion during the remaining 16m 38s was as follows:—

For 2m 48s, the motion was composed of well pronounced quick vibrations, superposed on traces of slow undulations.

For the next 2m 31s, there were 9 well defined slow regular undulations, (max. 2a=0,1 mm) of an average period of 16,8s, forming the second max. group.

For the next 2m 25s, the motion was small and quick-perioded.

For the next 2m 14s, there were 8 slow and regular waves (max. 2a=0,08 mm) of an average period of 16,8s, forming the third max. group.

For the next 2m 5s, the motion was again small and quick-perioded.

For next 4m 35s, there were 17 well defined slow undulations (max. $2a=0,08$ mm) and of an average period of 16,2s, forming the fourth max. group.

The E.P. consisted of small regular vibrations whose max. $2a$ was less than 0,05 mm, and which showed occasional alternations of max. and min. groups. The average period was:—

9,2s (measured at the commencement),
8,7 („ towards the very end).

(NS component).

The 1st P.T. lasted for 9m 33s, and consisted of vibrations, whose max. $2a$ was 0,03 mm and whose average period was 6,3s.

The 2nd P.T. lasted for 9m 7s and consisted of vibrations whose max. $2a$ was 0,07 mm and whose average period was 8,1s. There were alternations of max. and min. groups. Thus, beginning with the commencement of the 2nd P.T., that is 10h 56m 14s:—

for the first 40s, the motion was small;
then occurred a single max. vibration;
then the amplitude became very small;
at 10h 57m 47s commenced a max. group, lasting 58s;
at 10h 59m 44s commenced another max. group, lasting 34s;
at 11h 0m 26s commenced a third max. group, lasting 39s, etc.

The P.P. began gradually. For the first 1m 30s the motion was small, the average period being 15s. Then followed 8 large slow undulations which together occupied 3m 12s, and had an average period of 31,5s, their max. (abs.) $2a$ being 0,14 mm. These were followed by small vibrations which lasted 2m 56s. During the next 1m 28s the motion was slightly increased. Thereafter it became small and the predominating vibrations had an average period of 14s, superposed with vibrations of shorter period.

The E.P. The average period, measured towards the end, was 8,9s.

P.O. The max. 2a was 0,04 mm in each component, the average period being as follows:—

5,1s (measured at about $7\frac{1}{2}$ a.m., April 18th),
 4,9s („ „ $6\frac{1}{2}$ „ „).

Eqke No. 130. April 23rd 1899; 0h 15m 2s a.m.

Total duration = 3m.

This was a small earthquake at some distance. The commencement was somewhat obscured by P.O. The P.P., however, occurred about 2m after the assumed beginning.

The P.P. lasted 1m 29s. The average period was 7,4s, and the max. 2a was 0,05 mm in the EW and 0,03 mm in the NS component.

The E.P. was obscured by P.O.

P.O. The max. 2a was 0,05 mm in each component and the average period, measured 1h before the earthquake, was 4,0s.

Eqke No. 133. May 2nd 1899; 11h 36m 47s p.m.

Total duration = 1h.

This was a small earthquake at a great distance, and the motion began very gradually.

(EW component).

The P.T., whose duration was 5m 19s, was well defined and showed traces of vibrations of an average period of 7,2s.

The P.P., whose duration was about 16m, consisted of regular vibrations of an average period of 8,8s, the max. 2a being 0,09 mm. There were several alternations of max. and min. groups; the average interval between successive maxima being 1,5 m.

The E.P. The average period, measured towards the end, was 9,8s.

(NS component).

The P.T. lasted 5m 42s.

The P.P. The max. 2a was 0,08 mm.

Eqke No. 138. May 14th 1899; 10h 56m 31s p.m.

Total duration = 24m.

The beginning was somewhat obscure.

(EW component).

The P.T. lasted for about 5m.

The P.P. consisted of undulations of an average period of 16,7s, superposed with small vibrations of an average period of 5,6s. The max. 2a was 0,05 mm, the group of most active movements occurring at $3\frac{1}{2}$ m from the commencement.

(NS component).

The P.T. lasted about 4m. (?)

The P.P. The average period was about 19s, the max. 2a being 0,05 mm.

Eqke No. 139. May 15th 1899; 9h 57m 53s p.m.

Total duration = 37m.

(NS component).

The P.T., whose duration was 5m 45s, showed traces of vibrations of an average period of 6,4s.

The P.P., whose duration was 9m 0s, consisted of vibrations of an average period of 8,7s, the max. 2a being 0,04 mm.

In the E.P. the motion was very small.

(EW component).

The max. 2a was 0,03 mm.

Eqke No. 140. May 18th 1899; 4h 1m 45s a.m.

Total duration = 30m.

This was a small earthquake at a distance. The motion was very small.

Eqke No. 141. May 26th 1899; 11h 38m 28s p.m.

Total duration = about 13m.

This was a very small earthquake at some distance.

The P.T. lasted for about 51s.

The P.P. The average period was 6,4s. The max. 2a was less than 0,02 mm in each component.

Eqke No. 143. June 5th 1899; 1h 37m 43s p.m.

Total duration = 2h.

This was evidently a large earthquake at a very great distance.

(NS component).

The 1st P.T., whose duration was 17m 25s, began with very small vibrations of 2a less than 0,02 mm. The average period during the first half of this epoch was 5,6s and that during the remaining half was 8,1s.

The 2nd P.T., whose duration was 16m 13s, consisted of well defined regular undulations, the max. 2a of 0,04 mm occurring at the commencement. The average period was as follows:—

10,7s (at the commencement),

10,9 („ „ end).

The P.P. began very gradually with small slow undulations. After 5m 0s there appeared well defined undulations of an average period of 23,7s, which lasted for 17m 0s. Then followed the maximum group of waves (2a = 0,05 mm), which was somewhat quicker and had an average period of 18,2s.

There was no demarcation between the P.P. and the P.T.

(EW component).

The 1st P.T. lasted 17m 45s.

The 2nd P.T. lasted for 18m 28s, the max. 2a of 0,03 mm occurring at the commencement.

The P.P. The max. 2a was 0,02 mm.

P.O. The amplitude was very small.

Eqke No. 145. June 10th 1899; 3h 35m 20s p.m.

Total duration = about 33m.

The beginning of the motion was somewhat obscure, owing to the existence of slight P.O.

(EW component).

The P.T. lasted for 5m 5s and had an average period of 5,1s. The motion was very small.

The P.P. consisted of small but well defined undulations of an average period of 9,8s; the max. 2a of 0,04 mm occurring near the beginning. The motion showed a series of alternations of max. and min. groups.

(NS component).

The motion was very small.

P.O. The amplitude was very small. Its average period, measured 1h before the earthquake, was 4,3s.

Eqke No. 146. June 13th 1899; 4h 31m 18s a.m.

Total duration = about 26m.

The motion began very gradually and the P.T. was not well defined. The time interval between the assumed commencement and the occurrence of the max. motion was about 1m 25s.

The P.P. lasted about 18m, the max. 2a being 0,05 mm in the EW and 0,04 mm in the NS component. The average period, measured at the commencement, was about 11s.

The E.P. The average period was about 11s.

Eqke No. 147. June 14th 1899; 8h 27m 46s p.m.

Total duration = 1h 24m.

This was a large earthquake at a great distance. The motion began gradually with very small vibrations clearly recorded, there being no P.O. (NS component).

The 1st P.T., whose duration was 9m 10s, consisted uniformly of small vibrations of an average period of 4,9s.

The 2nd P.T. whose duration was 6m 40s, consisted of larger and somewhat slower vibrations of an average period of 7,1s. The max. 2a was 0,03 mm, the motion being larger at the commencement and end, than at the middle, of this epoch.

The P.P. began with traces of slow undulations. It was only 18m

40s later on that there appeared small but well defined waves, which lasted for 11m 25s and had an average period of 30s. After this the vibrations became gradually most active, and their max. 2a of 0,05 mm occurred at 9h 22m 32; the average period deduced from two successive groups of 50 waves being as follows:—

$$\left. \begin{array}{l} 18,4s \\ 16,4 \end{array} \right\} \text{ (General mean)} \\ 17,4s.$$

There were alternations of max. and min. epochs; the max. groups occurring at an average interval of about 4m.

(EW component).

The 1st P.T. lasted for 7m 38s.

The 2nd P.T., whose duration was 8m 45s, had an average period of about 7,4s.

The P.P. began with ill defined traces of slow undulations. 20m 40s later on there appeared small but well defined waves, which lasted for 8m 54s and had an average period of 23,2s. Thereafter the motion increased and quickened, the max. 2a of 0,04 mm occurring at 37m 34s from the commencement of this epoch. The average period of these latter waves, measured from two successive groups of 30 vibrations, was as follows:—

$$\left. \begin{array}{l} 18,8s \\ 17,0 \end{array} \right\} \text{ (General mean)} \\ 17,9s.$$

Eqke No. 149. June 16th 1899; 2h 49m 10s p.m.

Total duration = 25m.

This was a small earthquake at some distance.

(EW component).

The 1st P.T., whose duration was 3m 40s, consisted of very small vibrations of an average period of 2,7s.

The 2nd P.T., whose duration was 2m 46s, consisted of traces of waves of an average period of 7,5s, superposed with the small vibrations of the same nature as those in the 1st P.T.

The P.P., began with a group of most active waves, whose max.

(abs.) 2a was 0,06 mm and whose average period was 12,4s. There were alternations of max. and min. epochs, each of which comprised 4 to 6 waves. The average interval between the successive maxima was about 1,9m.

(NS component).

The total duration of the 1st and 2nd P.T.'s was 6m 30s.

The P.P. The max. 2a was 0,02 mm.

Eqke No. 152. June 19th 1899; 9h 2m 22s p.m.

Total duration = 31m.

This was a small earthquake at some distance.

The P.T., whose duration was 3m 38s, consisted of very small vibrations of an average period of 5,0s.

The P.P. The max. 2a of 0,04 mm in the EW and 0,03 mm in the NS component occurred at 9m from the beginning of the earthquake. The average period was 7,9s.

Eqke No. 153. June 24th 1899; 11h 46m 3s a.m.

Total duration = 15m.

This was a very small earthquake at some distance.

The maximum epoch, which lasted for about 6m, commenced at 4m 10s after the beginning of the earthquake. The average period was 7,3s.

Eqke No. 154. June 25th 1899; 1h 12m 28s a.m.

Total duration = 33m.

This was a small earthquake at a great distance, and the motion began gradually with very small vibrations.

(NS component).

The P.T. lasted for 14m 52s and consisted of small vibrations of an average period of 7,8s, the amplitude being rather greater at the commencement than at the end.

The P.P. For the first 1m 20s the motion was small. For the next 8m 55s the waves were well defined, the max. 2a being 0,08 mm and the average period 15,7s. These waves were distributed into 6 max. and

min. groups, the average interval between the successive maxima being 1,5m.

(EW component).

The P.T. lasted for about 19m 55s, the motion being very small.

The P.P. For the first 2m, the motion was small. Then followed well defined vibrations, which lasted for 11m, and whose average period was, during the earlier 5½m, 16,5s and, during the remaining 6m 12s, 12,4s. The max. 2a of 0,04 mm occurred at about 6m from the commencement.

Eqke No. 155. June 25th 1899; 2h 25m 42s a.m.

Total duration = 36m.

This was a small earthquake at a great distance and the motion began very gradually.

The P.T., whose duration was 19m 55s, consisted of very small vibrations with an average period of 9s.

The P.P., whose duration was 7m 35s, had an average period of 16,8s, the max. 2a being about 0,04 mm in each component.

The E.P. The average period was 11s.

Eqke No. 156. July 4th 1899; 0h 44m 11s a.m.

Total duration = 24m.

This was a small earthquake at some distance.

The P.T., whose duration was 3m 44s, consisted of traces of very small undulations of an average period of about 4,3s.

The P.P., whose duration was 3m, had an average period of 7,5s. The max. 2a was 0,03 mm in each component.

The E.P. The average period was 9,5s.

This earthquake was observed at the Meteorological Observatories of Kagoshima and Ōshima as follows:—

Kagoshima	.. ..	0h 42m 58s a.m.	.. ..	Slight.	Motion gentle.
Ōshima	.. ..	0. 40. 0	.. ..	„	Houses shaken.

Eqke No. 162. July 12th 1899; 11h 56m 26s p.m.

Total duration = 1h 25m.

(NS component).

The P.T., whose duration was 3m 51s, had an average period of 7,3s, there being also traces of small vibrations of an average period of 4,3s. The amplitude was slightly greater in the earlier than in the later part, the max. 2a being 0,16 mm.

The P.P., whose duration was about 7m, began with the max. 2a of 0,34 mm. During the first 1m 14s, when the motion was most active, the average period was 10,6s. Then followed quicker vibrations (max 2a = 0,25 mm) of an average period of 6,8s.

The E.P. The average period was as follows:—

8,2s (at the commencement),

10,1 (1h after the beginning of the earthquake).

(EW component).

The P.T. lasted 3m 45s, the max. 2a being 0,14 mm. The average period was 6,2s, there being also traces of smaller vibrations.

The P.P., whose duration was 5m 24s, began with the max. 2a of 0,5 mm. During the first 1m 31s the average period was 11,4s. Towards the end (max. 2a = 0,3 mm) the average period was 7,3s.

The E.P. The average period was as follows:—

8,5s (at the commencement),

10,0 (1h after the beginning of the earthquake).

Eqke No. 163. July 14th 1899; 9h 6m 3s p.m.

Total duration = 3h.

This was a large earthquake at some great distance. The beginning of the motion is clearly defined, the very first displacement being 0,05 mm towards E and 0,1 mm towards N, followed by a decided counter displacement of 0,55 mm towards W and 0,5 mm towards S.

(EW component).

The P.T. Throughout this epoch, which lasted for 8m 28s amplitude

did not much vary. There was, however, a slight increase in amplitude at 2m 47s from the commencement, denoting probably the appearance of the 2nd P.T. The motion consisted of vibrations (max. $2a=0,6$ mm) of an average period of 6,2s, superposed on slower and larger undulations (max. $2a=0,8$ mm) of an average period of 14,2s. It is to be noted that in this case the motion was active from the very beginning of the P.T., which did not consist of small vibrations as generally happens.

The P.P., whose duration was 6m 40s, began with three slow undulations of an average period of 30s, superposed with small vibrations of an average period of 7,0s. Then followed 4 well defined waves, which together occupied 2m 10s and had an average period of 33s. Of these, the 3rd vibration, which was the absolute maximum ($2a=6,6$ mm), occurred at 2m 32s from the commencement. The next three waves had an average period of 31s.

The E.P. showed occasional alternations of maximum and minimum epochs. The average period, deduced from 3 groups of 80 vibrations was as follows:—

- 9,9s (in the earlier part),
- 9,0 (at about 1h after the beginning of the eqke),
- 9,6 („ „ 2hs „ „ „ „).

(NS component).

The 1st P.T., whose duration was 2m 48s, consisted of vibrations (max. $2a=0,75$ mm) of an average period of 15s, superposed with others (max. $2a=0,02$ mm) of an average period of 7,1s. The amplitude remained nearly constant.

The 2nd P.T., whose duration was 4m 16s, began with a prominent (max.) displacement of 1,45 mm, and consisted of vibrations of an average period of 10,7s, superposed with others of an average period of 5,7s. There seemed to exist also traces of still quicker vibrations.

The P.P., whose duration was about 9m 20s, began with a well defined vibration of ($2a=1,5$ mm), the succeeding 4 vibrations having smaller amplitude and an average period of 20s. The most active part

of the P.P., began at 1m 38s after its commencement and lasted for 3m 0s, consisting of 12 undulations of an average period of 15s. The absolute max. 2a of 3,2 mm occurred at 9h 16m 26s p.m. Later on the motion consisted of regular vibrations of an average period of 9,4s.

The E.P. The average period deduced from three groups of 80 vibrations was as follows :—

9,3s (in the earlier part ; these being superposed on undulations of an average period of 15,8s),

9,4 (1h after the beginning of the eqke),

9,0 (2hs „ „ „ „ „).

General mean 9,2s.

Eqke No. 165. July 17th 1899 ; 1h 59m 23s p.m.

Total duration = 2h 2m.

This was a large earthquake at a distance.

(EW component).

The P.T., whose duration was 4m 45s, had an average period of 45s.

The P.P., whose duration was 10m 30s was characterized by the appearance of slow undulations. During the first 1m 45s the motion was ill defined. During the next 5m 8s, however, there appeared a max. group, consisting of 15 conspicuous waves of an average period of 20s. These were superposed with small vibrations of an average period of 5,6s. After this predominated waves of an average period of 12,8s, which lasted for 3m 50s, and of which the last 1m 38s interval formed the most active portion of the earthquake, the max. 2a of 0,15 mm occurring at 2h 13m 4s.

The E.P. The average period deduced from two groups of 50 vibrations, was as follows :—

11,3s (at the commencement),

10,0 (towards the end).

There were some alternations of max. and min. epochs.

(NS component).

The 1st P.T. was well defined and lasted for 4m 12s. In the earlier

part predominated small vibrations of an average period of 3,6s, while in the later part predominated those of an average period of 5,9s.

The 2nd P.T., whose duration was 2m 30s, began with well defined small vibrations, whose max. 2a was 0,05 mm, and whose average period was 6,5s.

The P.P. began with 15 slow undulations, which lasted for 4m 58s and had an average period of 20s. These were followed by quicker active vibrations, which began with the (abs.) max. 2a of 0,06 mm and had an average period of 13,7s.

Eqke No. 166. July 17th 1899 ; 7h 48m 2s p.m.

Total duration=about 29m.

This was a small earthquake at a distance.

The P.T. lasted for about 3m 40s.

The P.P. The max. 2a was 0,02 mm in each component. The average period was 17,4s.

Eqke No. 168. July 21st 1899 ; 7h 25m 55s a.m.

Total duration=about 18m.

This was a small earthquake at some distance and the motion consisted mainly of regular vibrations.

(NS component).

The P.T., whose duration was about 1m 28s, had the max. 2a of 0,04 mm and an average period of 3,0s, there being also traces of slow undulations.

The P.P. consisted of a great number of nearly similar vibrations, whose average period was 4,2s. The max. 2a of 0,07 mm occurred at about 6m from the beginning of the earthquake.

The E.P. The average period, measured towards the end, was 6,3s.

The EW component diagram was not obtained, as the earthquake took place during the change of the record-receiver of that component apparatus.

Eqke No. 169. July 24th 1899; 10h 23m 33s a.m.

Total duration = 1h 45m.

This was a large earthquake at a great distance.

(NS component).

The P.T. lasted for about 3m 19s and had an average period of 12,4s.

(The beginning was slightly confused by the presence of small P.O.)

The P.P., whose duration was 21m, began with a group of vibrations which formed the most active part of the motion, the max. 2a being 0,18 mm. Thereafter the motion remained nearly constant in amplitude, except for alternations of max. and min. epochs. The average period, deduced from three successive groups of 30 vibrations, was as follows:—

9,7s	}	(General mean)	10,1s.....	(measured near the commence-	
10,3					ment of the P.P.)
10,4					

The E.P. The average period deduced from three successive groups of 30 vibrations taken at about 1h after the commencement of the earthquake was as follows:—

10,3s	}	(General mean)	9,8s.
10,1			
9,0			

(EW component)

The P.T. lasted for about 3m 0s, the motion being very small.

The P.P. The max. 2a of 0,1 mm occurred at the commencement. The first 17 undulations which together occupied an interval of 3m 46s, and had an average period of 13,3s, formed the most active part of the motion. Then followed regular and somewhat quicker vibrations (max. 2a = 0,1 mm), whose average period, deduced from three successive groups of 30 vibrations was as follows:—

10,3s	}	(General mean)	10,3s.
9,9			
10,8			

Eqke No. 171. July 29th 1899; 6h 23m 18s a.m.

Total duration=20m.

This was a small earthquake at a comparatively great distance. The beginning of the motion was somewhat obscure on account of the presence of P.O.

(EW component).

The P.T. was not well defined, but the motion began with small vibrations of an average period of 7,8s. The max. 2a of 0,05 mm occurred at 3m 10s from the commencement.

(NS component).

The max. 2a was 0,02 mm.

P.O. The average period, measured immediately before the earthquake, was 3,8s.

Eqke No. 172. July 30th 1899; 4h 44m 6s a.m.

Total duration=41m.

This was a very small earthquake at some distance.

(NS component).

The motion began gradually and the P.T. was not well defined.

Near the beginning the average period was 7,0s. In the most active part of the motion, at about 16m from the commencement, it was 14s. The max. 2a was 0,02 mm. (The EW component diagram was lost by accident.)

Eqke No. 173. July 31st 1899; 1h 30m 11s a.m.

Total duration=about 22m.

This was a small earthquake at some distance.

The P.T. was not well defined, the motion gradually becoming larger. The max. 2a was 0,04 mm in the EW and 0,02 mm in the NS component. The average period was as follows :—

- 7,4s (at the commencement of the P.P.),
- 7,9 (in the most active part of the P.P.),
- 8,0 (near the end of the earthquake).

Eqke No. 177. August 4th 1899; 1h 50m 2s p.m.

Total duration = 2h 19m.

This was a large earthquake at a great distance.

The beginning, the 1st and 2nd P.T.'s, and the P.P. were all clearly defined.

(EW component).

The 1st P.T., whose duration was 6m 6s, began with small waves of an average period of 2,6s, superposed on slower vibrations of an average period of 9,1s. After 2m 26s there appeared well defined vibrations of an average period of 7,0s, whose max. 2a of 0,4 mm occurred 1m 50s later on. This maximum motion was, however, by no means a prominent one, the amplitude remaining sensibly constant throughout this epoch except at its commencement.

The 2nd P.T., whose duration was 3m 25s, consisted of well defined vibrations (which were not at all small tremors) of an average period of 6,0s, superposed more or less distinctly on slower waves of an average period of 13,6s. There existed also some ill defined traces of still slower undulations.

The 2nd P.T. began with its maximum vibration whose period was 14s and whose first and second displacements were as follows:—

$$\begin{aligned} \text{(1st displ.)} & \left\{ \begin{array}{l} 1,28 \text{ mm towards E,} \\ 0,6 \quad \text{,,} \quad \text{,,} \quad \text{S.} \end{array} \right. \\ \text{(2nd displ.)} & \left\{ \begin{array}{l} 2,2 \text{ mm} \quad \text{,,} \quad \text{W,} \\ 1,04 \text{ ,,} \quad \text{,,} \quad \text{N.} \end{array} \right. \end{aligned}$$

The resultant ranges of these two displacements were respectively 1,4 mm and 2,4 mm, their directions being S 65° E and N 62° W.

The P.P. lasted for 5m 20s and began with two slow undulations whose 2a was 1,7 mm and whose period was 32s. Then followed two large proper pendulum oscillations of an average period of 28s, their maximum 2a of 12,4 mm occurring at 2h 1m 14s. After these there appeared four slow undulations of an average period of 37s, the first of

which had a max. 2a of 4,7 mm. The succeeding motion was very much smaller.

The E.P. consisted of regular simple waves. The average period, deduced from two successive groups of 100 vibrations taken at 45 m after the commencement of the earthquake was as follows :—

$$\begin{array}{r} 9,3s \\ 8,8 \end{array} \left. \vphantom{\begin{array}{r} 9,3s \\ 8,8 \end{array}} \right\} \begin{array}{l} \text{(General mean)} \\ 9,1s. \end{array}$$

There were no marked alternations of max. and min. movements. (NS component).

The 1st P.T., lasted for 6m 8s and began with a vibration whose 2a was 0,3 mm and whose period was 10,9s. The motion consisted essentially of vibrations whose average period was 9,7s and whose max. 2a of 0,46 mm occurred near the middle of this epoch. There were also traces of smaller vibrations of an average period of 5,6s.

The 2nd P.T. began with the maximum vibration and lasted for 3m 45s, the motion consisting essentially of waves of an average period of 13,3s, superposed with others of an average period of 6,5s. The 2nd P.T. was in this case not at all a tremor, its amplitude being nearly equal to that in the P.P. which followed it.

The P.P. lasted for about 11m 15s. The max. (abs.) 2a of 1,9 mm occurred at 2h 2m 16s, its period being 13,9s. The average period, measured towards the end of this epoch, was 16,4s. There were also traces of some slow undulations.

Eqke No. 185. August 14th 1899 ; 8h 55m 20s p.m.

Total duration = about 6m 30s.

This was probably a distant earthquake, and the diagram showed traces of small slow movements of an average period of 9,5s, superposed with quicker vibrations.

Eqke No. 186. August 18th 1899 ; 5h 46m 31s a.m.

Total duration = 1h 10m.

This was an earthquake at a great distance.

The motion began with very slight vibrations, but the commencement was clearly recorded. The 1st and 2nd P.T.'s as well as the P.P. were also well defined.

(EW component).

The 1st P.T. lasted for 9m 15s, the amplitude, which was very small, remaining nearly constant. The average period was about 8,3s.

The 2nd P.T., whose duration was 16m 30s, had an average period of 9s. The amplitude remained nearly constant throughout this epoch or rather the first half portion had a slightly greater amplitude than the second half. The max. 2a was 0,05 mm.

The P.P., lasted for 15m and consisted of well defined vibrations of an average period of 13,8s, whose max. 2a of 0,35 mm occurred at 6h 15m 28s.

The E.P. The average period deduced from two successive groups of 50 vibrations was as follows:—

$$\left. \begin{array}{l} 10,5s \\ 11,9 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 11,2s. \end{array}$$

(NS component).

The 1st P.T. lasted for 7m 25s.

The 2nd P.T. lasted for 16m 50s and had an average period of 8,6s, the max. 2a being 0,05 mm. The motion was most active at the commencement, but practically nil towards the end.

The P.P. whose duration was 13m had an average period of 13,5s. The motion presented a series of alternations of max. and min. epochs, there being, in particular, five conspicuous maximum movements which occurred respectively at 6h 11m 46s, 6h 14m 18s, 6h 16m 53s, 6h 19m 13s and 6h 21m 23s. The fourth was the absolute maximum, its 2a being 0,35 mm.

The E.P. The average period deduced from two successive groups of 50 vibrations taken at the commencement was as follows:—

$$\left. \begin{array}{l} 12,3s \\ 12,2 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 12,3s. \end{array}$$

P.O. The amplitude was very small. The average period, measured 3hs before the commencement of the earthquake, was 4,2s.

Eqke No. 187. August 21st 1899; 1h 11m 44s a.m.

Total duration = about 22m.

This was a small earthquake at a great distance. The motion was very small.

(NS component).

The P.T. lasted for 7m 55s and consisted of very small vibrations of an average period of 7,1s.

The P.P. consisted of a great number of nearly similar regular vibrations of an average period of 10,5s. The max. 2a was 0,025 mm.

(EW component).

The motion was much smaller than in the NS component.

Eqke No. 188. August 25th 1899; 0h 20m 7s a.m.

Total duration = 1h 10m.

This was a large earthquake at a great distance. The commencement was clearly recorded and the 1st and 2nd P.T.'s as well as the P.P. were well defined.

(NS component).

The 1st P.T. lasted for 9m 0s. During the first 4m the motion was small, the max. 2a being 0,05 mm and the average period 4,8s. In the remainder of this epoch, the amplitude was nearly the same as before, but the average period was lengthened to 10,4s.

The 2nd P.T., whose duration was 8m 33s, began with a group of 9 most active movements, occupying together 1m 29s. Their average period was 9,9s and the max. 2a of 0,22 mm occurred near the end of the series. The following motion consisted of uniform regular vibrations, which decreased towards the end, the average period being 7,0s.

The P.P., whose duration was 12m 20s, began gradually with small slow undulations. During the first 8m 55s, the average period was 27s, the amplitude becoming somewhat prominent first at 6m 0s after the

commencement of the P.P. At 0h 46m 26s appeared 4 well defined waves, which formed the most active part of the motion and whose 3rd vibration had a max. 2a of 0,2 mm; their average period was 22s. The following movements were much smaller, their average period being 19,4s.

The E.P. here comprises the part of the motion whose amplitude was not at all small, but whose period was somewhat quicker than in the P.P. The average period deduced from two successive groups of 50 vibrations (taken at the commencement) was as follows:—

$$\begin{array}{r} 17,9s \\ 16,5 \end{array} \left. \vphantom{\begin{array}{r} 17,9s \\ 16,5 \end{array}} \right\} \begin{array}{l} \text{(General mean)} \\ 17,2s. \end{array}$$

The motion showed a series of alternations of max. and min. vibrations there being, during the first 30m, 9 max. and 9 min. groups.

(EW component).

The 1st P.T. lasted for 10m 5s. During the first 3m 35s, the motion was small, the max. 2a being 0,03 mm; the average period was 4,3s. The following vibrations had an average period of 6,9s, the max. 2a being 0,06 mm.

The 2nd P.T., whose duration was 10m 5s, had an average period of 8,9s. The amplitude was greater at the beginning than at the end. The max. 2a of 0,15 mm occurred at 0h 32m 57s.

The P.P. The max. 2a was 0,08 mm, the motion being smaller in this than in the NS component.

Eqke No. 189. August 26th 1899; 7h 7m 11s a.m.

Total duration = about 20m.

This was a small earthquake at some distance.

The commencement was somewhat obscure, but the 2nd P.T., and the P.P. were well defined.

(EW component).

The 1st P.T. lasted about 42s.

The 2nd P.T. lasted for 1m 13s and consisted of small but distinct

vibrations of an average period of 2,6s. The amplitude remained nearly constant, or rather slightly decreased towards the end.

The P.P. lasted for 3m 46s and began with 5 principal undulations whose average period was 10,9s; the 3rd vibration having the maximum 2a of 0,2 mm in the EW and 0,12 mm in the NS component. The remaining portion had an average period of 9,0s. The motion showed in the EW component three alternations of max. and min. movements, the maximum occurring respectively at 2m 19s, 3m 33s and 4m 59s from the commencement of the earthquake.

The E.P. The average period, deduced from three successive groups of 50 vibrations, was as follows:—

$$\left. \begin{array}{l} 7,1s \\ 7,0 \\ 7,4 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 7,2s \end{array}$$

(NS component).

The P.T. lasted about 2m 36s.

Eqke No. 190. August 26th 1899; 1h 58m 29s p.m.

Total duration = about 20m.

This was a small earthquake at some distance. The diagram is very similar to that of the preceding earthquake No. 189.

The 1st P.T. lasted for 1m 11s.

The 2nd P.T. lasted for 1m 2s and consisted of well defined quick vibrations of an average period of 3,1s. The max. 2a was 0,03 mm in each component.

The P.P. lasted for 3m 32s and began with four well defined large vibrations of an average period of 10,1s; of these the last movement was the maximum, its 2a being 0,18 mm in the EW and 0,17 mm in the NS component. The succeeding waves had an average period of 9,2s. The motion showed in the EW component three maximum groups, occurring respectively at 2m 49s, 4m 2s and 5m 33s after the commencement of the

earthquake. Such an alternation of the max. and min. movements was not indicated in the NS component.

The E.P. The average period deduced from two successive groups of 50 vibrations was as follows:—

$$\begin{array}{r} 7,8s \\ 7,2 \end{array} \left. \vphantom{\begin{array}{r} 7,8s \\ 7,2 \end{array}} \right\} \begin{array}{l} \text{(General mean)} \\ 7,5s. \end{array}$$

Eqke No. 193. September 4th 1899; 9h 31m 59s a.m.

Total duration = 3h.

This was a very large earthquake and originated, as eqkes Nos 196 and 197, off the south-west coast of Alasca. The following extract is taken from the *Japan Times* of October 31st 1899.—

A big Alaskan Earthquake.

Port Townsend (Wash.) Sept. 24.—Concerning the recent earthquakes along the coast of Alasca, the reverend Sheldon Jackson, United States Educational Agent for Alasca, writes as follows from Yakutat under date of Sept. 17th.

„ The first shock was experienced on Sunday, Sept. 3rd, but being slight, caused no alarm. During the following week other shocks were felt, and people began to get nervous. On Sept. 10th, at 9.20 a.m. shocks became so violent as to cause genuine apprehension. During the following five hours there were fifty-two distinct shocks, culminating at 3 p.m. in a shock so severe that the people of Yakutat were hurled violently across their rooms, or, if outside, thrown to the ground, while pictures fell from the walls and clocks and dishes crashed from the shelves and houses rocked and swerged and whirled, while the mission bell rang violently in the Skakine Church tower.

„ Paine stricken, the inhabitants regained their feet and attempted to flee to the hills, only to be again thrown to the earth, all the while creaking. Gaining the hills and looking seaward, they were transfixed with horror as they saw a great tidal wave apparently a wall of

water 30 feet high, approaching with the speed of a race horse, that would engulf their village and sweep away their homes. Before the shore was reached the earth opened in the bottom of the harbour and into this chasm the tidal wave spent its force, and around it the sea swelled like a great maelstrom. This saved the village from destruction.

„ The tide would rise ten feet in the space of four or five minutes and in an equally short time go down again. These sudden fluctuations being frequently repeated, tents were pitched on the hills back of the village and nearly the whole population are camping out, fearing that another tidal wave may come. From the 10th to the present time there have been frequent shocks, one having occurred this forenoon..... Great spruce forests for miles along the shore were uprooted, broken into pieces and massed into great piles with a roar that was deafening. Large rocks weighing forty tons or more were rolling over one another down the mountain like so many pebbles. Hubbard glacier, with its two and a half miles of sea front, thousands of feet thick, extending for miles back to the summit of the mountain, broken from its moorings and with a grinding indescribable roar that shook the surrounding hills moved bodily from half to three-quarters of a mile into the sea. Mountains were thrown down, the sea opened and portions of islands disappeared.....

„ Rumours are afloat that a portion of Cape St. Elias and Khamtaak island have disappeared in the sea.....”

(EW component).

The 1st P.T., whose duration was 7m 36s, consisted of vibrations of an average period of 7,9s (max. $2a=0,25$ mm), superposed with still smaller ones of an average period of 3,5s (max. $2a=0,15$ mm). There were also traces of slow undulations of an average period of 18s. The commencement was small and gradual, but distinct, the amplitude remaining on the whole constant.

The 2nd P.T., lasted for 9m 38s and began with a motion of 0,46 mm

towards W followed by a well pronounced undulation whose period was 34s and which consisted of the two displacements :—

- (1st) 2,5 mm towards E,
 (2nd) 4,1 „ „ W.

For the next 6m 12s the amplitude did not much vary and was slightly smaller than that of the above introductory wave the average, period being 25,2s. After these, took place two conspicuous undulations of an average period of 34,5s, the first of which had the max. 2a of 5,6 mm. There were also traces of slow undulations with an average period of 1m 6s. It is to be remarked that the 2nd P.T. was in this case not at all a small insignificant tremor but consisted of large well defined waves.

The P.P. lasted for 22m, and began with seven large undulations which together occupied 3m 48s and had an average period of 32,6s; the second having the max. (abs.) 2a of 15,2 mm. These vibrations, which were apparently produced by the composition of the proper oscillations of the pendulum with the earthquake motion, were arranged as follows :—

- 1st motion : 5,5 mm towards W,
 2nd „ : 11,3 „ „ E;
 then followed the max. motion above noted ;
 the next vibration was a little smaller ;
 the two next ones were small ;
 then followed the second max. 2a of 13,8 mm.

After these the motion became quicker, the average period during the next 4m 42s being 23,5s. For the next 4m 51s the motion consisted of well defined vibrations, whose max. 2a was 4,8 mm and whose average period 16,2s. During the remaining part the average period was 14,9s.

The E.P. For the first 26m the motion was more or less large, the average period of the principal vibrations being 16,2s. There were also traces of slower undulations of an average period of 51s and of others of an average period of 24s. During the next 12m 30s, the principal waves had an average period of 20,8s, superposed with smaller vibrations. From

about 1h 45m after the commencement of the earthquake, the motion consisted essentially of regular waves, whose average period, deduced from three successive groups of 50 vibrations, was as follows:—

$$\left. \begin{array}{l} 10,4s \\ 10,9 \\ 10,3 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 10,5s. \end{array}$$

Eqke No. 196. September 11th 1899; 3h 14m 16s a.m.

Total duration = about 3h.

(EW component).

The 1st P.T. lasted for 7m 38s and consisted of small vibrations of an average period of 6,8s.

The 2nd P.T. lasted for 6m 53s.

The P.P. The max. 2a was 2,6 mm and the average period was 32s.

The E.P. The average period, measured at about 1h after the commencement of the earthquake, was 10,4s.

Eqke No. 197. September 11th 1899; 6h 50m 58s a.m.

Total duration = 4h.

This was a very large earthquake and, like the two preceding ones, originated off the south-western coast of Alasca. It appears that, at the origin, shocks happened almost continuously after the eqke No. 196, the diagram showing more or less distinct traces of motion throughout the time interval between the latter and this earthquake.

(EW component).

The 1st P.T., whose duration was 7m 43s, consisted of small vibrations of an average period of 4,3s, superposed on larger ones of an average period of 9,3s.

The 2nd P.T., whose duration was 6m 30s, began with a well defined displacement of 2 mm towards E, followed by 14 large undulations with an average period of 27s,

The P.P., whose duration was about 15m, began with four very slow undulations with an average period of 41s. Then followed five large

proper oscillations of the pendulum, their max. $2a$ being 10,5 mm. The average period, measured at about 23m from the commencement of the earthquake, was 24s.

The E.P. The average period, measured at respectively 1h, 2h and 3h after the commencement of the earthquake, was as follows:—

9,9s	(deduced from 57 vibrations),	}	(General mean)
9,8	(„ „ 100 „),		
9,7	(„ „ 60 „),		
			9,8s.

It will be observed that in the three foregoing earthquakes, Nos. 193, 196, and 197, the 1st P.T. lasted for an almost exactly identical interval of time. This shows that these earthquakes originated very nearly at an equal distance from Tokyo. Assuming the position of their centres to be near the Cape St. Elias, the spherical distance between it and Tokyo would be about 6100 km.

Eqke No. 198. September 11th 1899; 8h 44m 35s p.m.

Total duration = about 19m.

This was a small earthquake at some distance. There were small P.O.

(EW component).

The 1st P.T., whose duration was 2m 5s, consisted of small vibrations of an average period of 3,9s, superposed on slower ones of an average period of 9,2s.

The 2nd P.T., whose duration was 1m 36s, commenced with the max. $2a$ of 0,08 mm. The motion consisted of well defined vibrations of an average period of 9,6s, superposed with smaller ones of an average period of 3,7s.

The P.P., whose duration was 3m 48s, consisted of regular well defined vibrations. The first 12 waves, which together occupied 1m 48s, had an average period of 9,0s and were of nearly an equal amplitude; the 2nd vibration having a max. $2a$ of 0,16 mm. The motion then remained

small for 43s, but was again increased for the next 1m 10s, the maximum 2a being 0,14 mm and the average period 9,2s.

The E.P. showed at first some insignificant alternations of max. and min. movements. The average period was 7,6s.

(NS component).

The max. 2a was 0,1 mm.

P.O. The average period, measured immediately after the earthquake, was 4,6s.

Eqke No. 200. September 17th 1899; 10h 1m 8s p.m.

Total duration=2h.

This was an earthquake at a great distance.

The P.T. lasted for about 9m 20s.

The P.P. consisted of small regular vibrations of an average period of 8,7s. The max. 2a was 0,05 mm in the EW and 0,02 mm in the NS component.

Eqke No. 201. September 20th 1899; 11h 24m 27s a.m.

Total duration=1h 15m.

This was the great Smyrna Earthquake. The *Japan Times* of November 12th had the following article.—

„Constantinople, October 2.—It is now estimated that 1500 Persians perished in the earthquakes in Asia Minor, around Aidin! The first shock occurred at 4 o'clock in the morning of September 20th and lasted 40 seconds. The effects were appalling. Whole villages were completely destroyed. The earthquake was felt as far as Scio, Mitylene and Smyrna.

„The latest advices from the stricken area show that men, women and children were buried in the ruins of their dwellings before they realized their danger. Numbers of bodies still lie beneath the debris. About 500 persons were killed at Sarakeni and some 500 at Denizli, where three-fourths of the buildings fell. There was proportionate loss of life in many of the smaller villages. The distur-

bance has not yet subsided, although its strength appears to be spent. The shocks continue almost daily, but with no great violence. The population is encamped in the open.

„ One consequence of the earthquake is the subsidence of the level of the Aidin district by two yards. Sulphurous springs burst out in the valley of Noander and the country between Aidin and Denizli became full of crevices, out of which rushed black, muddy water with sufficient volume to wash away a flock of 1000 sheep.

„ The villagers of the Valley of Noander report that for several days previous to the catastrophie domestic animals were greatly disturbed, bleating and barking.”

Assuming the origin of the earthquake to be in the vicinity of Denizli, the distance between it and Tokyo would be $82^{\circ} 26'$ or 9200 km along the great circle. The time of occurrence of the earthquake in Tokyo is, when referred to the meridian of Smyrna, about 4h 12m a.m.

(EW component).

The 1st P.T. lasted for 10m 19s and consisted of small vibrations of an average period of 6,0s, superposed more or less distinctly on traces of slower waves of an average period of 8,7s.

The 2nd P.T. lasted for 12m 0s and consisted of well defined vibrations of an average period of 10,5s, superposed with some minute vibrations.

The P.P. lasted for 21m. For the first 12m the motion consisted of very slow undulations, whose period was 42s, superposed with some small vibrations. After this, the movements became quicker, the average period deduced from two successive groups of 40 vibrations being as follows:—

$$\left. \begin{array}{l} 16,5s \\ 14,5 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 15,5s. \end{array}$$

The max. 2a of 0,9 mm (period 16,7s) occurred at 41 m after the commencement of the earthquake.

P.O. In the early morning of the 22nd the P.O. became prominent. Their average period deduced from three successive groups of 50

vibrations about 5h after the commencement of the earthquake, was as follows:—

$$\left. \begin{array}{l} 5,6s \\ 5,7 \\ 5,8 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 5,7s. \end{array}$$

Their max. 2a was 0,06 mm. [The NS component diagram was not satisfactorily registered, as the sharp conical point (the point of support) of the strut of the horizontal pendulum was damaged, indicating thereby only the proper oscillation of the latter.]

Eqke No. 202. September 23rd 1899; 8h 26m 22s p.m.

Total duration=about 24m.

There were some doubtful traces of a small earthquake at a distance. The record was confused by strong P.O.

Eqke No. 203. September 23rd 1899; 11h 8m 45s p.m.

Total duration=about 28m.

This was an earthquake at a distance. The diagram was somewhat confused by a strong storm of P.O.

(NS component).

At about 7m 30s from the commencement there appeared traces of slow undulations of an average period of 22s, whose max. 2a was 0,07 mm in the NS and doubtful in the EW component.

P.O. The average period was 8,0s, and their max. 2a was 0,05 mm in each component.

Eqke No. 205. September 28th, 1899; 3h 58m 14s p.m.

Total duration=about 19m.

This was a small earthquake at some distance. The P.T. was not well defined.

The max. 2a, which occurred at 4m 45s after the commencement, was 0,04 mm in the EW and 0,05 mm in the NS component. The average period was about 6,4s.

P.O. There were very small and quick P.O. whose average period, measured a few hours before the earthquake, was 3,4s.

Eqke No. 206. September 29th 1899; 8h 40m 28s p.m.

Total duration = 17m.

This was a small earthquake at a distance.

The P.T., whose duration was about 2m, had an average period of 3,3s.

The P.P. whose duration was about 4m had an average period of 8,9s; the max. 2a being 0,1 mm in each component.

Eqke No. 207. September 30th 1899; 2h 11m 0s a.m.

Total duration = 1h 30m.

This was the great earthquake which caused much damage along the south coast of the Ceran Island and in the Molluccas. The following extract is taken from Dr. J.P. van der Stok's paper, entitled "Two earthquakes, registered in Europe and at Batavia."*

1. In the night of 29 to 30 September 1899, a heavy earthquake caused serious damage at the south coast of the isle of Ceram and in the Molluccos.

„ The first official report, sent by the Resident of Amboina to the Governor-General immediately after the disaster, runs as follows :

„ In the night of 29 to 30 September at 1h 45m a.m. a heavy earthquake, followed by a series of sea-waves, caused considerable damage at the south coast of Ceram and, in a less degree, also at the isles of Ambon, Banda and the Ulias-isles. Several villages at Ceram's south coast have been devastated; in the Elpaputih-Bay all except two. The prison at Amahei has been completely destroyed, the fortifications partially, whereas the presbytery and the churches remained unhurt, as also the garrison and the civil officers at Amahei and Kairatoe.

* Koninklijke Akademie van Wetenschappen te Amsterdam. December 20 1899.

„ As the Government steamer Arend proved incapable of doing all the work, the steamers Gouverneur-General's Jacob and Japara of the Royal Pakketvaart-Company were chartered in order to convey victuals and medical assistance and for the transport of the wounded, whilst also the Resident of Ternate was requested to give assistance. Provisions and material for building are to be had at Ambon in sufficient quantities and have been provided immediately; but in other respects there is still much sufferance.

„ The steamers Jacob brought over to Amboina 27 wounded, whilst the Japara, by which boat the Resident and first medical officer went to the place of the disaster, conveyed 49 wounded from Amahei and Saparna.

„ From Banda, where the pier before fort Nassau has been destroyed, satisfactory information has been received.

„ According to preliminary reports the number of natives, killed by the disaster, amounts to 4000 and that of the wounded to 500.

„ The natives who survived have fled to the inland country and do not venture to come back to their hamlets: there is much agitation everywhere, where the effect of the earth and sea waves has been felt. The petroleum establishment at Bulobay has not suffered any damage.”

2. The seismograms, received from Dr. Figeé, show that this earthquake has been registered very neatly at the Royal Observatory at Batavia.

As far as I know this is the first case that an earthquake, originating in the Molluccos has been observed at Batavia by means of Milne's seismograph. The motion commences abruptly at 0h 14,6m Batavia time, which corresponds to 1h 43,3m local time, the difference in longitude between Amahei and Batavia being 1h 28,7m.

If we assume the origin of the earthquake to have been situated off the southern coast of the Island of Ceram, at a point long. 129° E, lat. 6° S, the distance along the great circle between the origin and Tokyo would be 4800 km, and that between the origin and Batavia about 1950 km.

(EW component).

The 1st P.T., whose duration was 5m 46s, consisted of vibrations of an average period of 8,9s, superposed with smaller ones of an average period of 3,6s.

The 2nd P.T., whose duration was 3m 39s, consisted of vibrations of an average period of 8,4s, superposed more or less distinctly on traces of slow undulations.

The P.P. lasted for about 10m and began with the conspicuous maximum undulation, whose period was 33s, and whose two displacements were as follows:—

(first motion) 3,3 mm towards W,
 (second „) 5,4 „ „ E.

The undulations which followed this maximum were far smaller than the latter, their average period being 20s.

The E.P. The average period, measured at about 1h after the commencement of the earthquake, was 12s.

The NS component of this earthquake as well as of the following was not satisfactorily recorded, on account of the same circumstance as with eqke No. 201.

Eqke No 210. October 4th 1899; 5h 56m 22s p.m.

Total duration = 1h 5m.

(EW component).

The P.T., whose duration was 2m 0s, consisted of small vibrations of an average period of 2,9s.

The P.P. lasted for about 10m and began with eight slow undulations which together occupied 2m 10s and had an average period of 16,3s; the third vibration having the max. 2a of 0,2 mm. Then followed for the next 7m 55s well defined and quicker vibrations of an average period of 11,9s. There were also traces of small movements of an average period of 4,1s, these being recognizable till 8m after the commencement of this epoch.

The E.P. The average period, deduced from three successive series

of 50 vibrations, taken at 30m after the beginning of the motion, was as follows:—

8,9s	}	(General mean)
9,4		
9,9		
		9,4s.

(NS component).

The P.T. lasted for about 2m 0s.

The P.P. For the first 2m 45s, the motion consisted of ten slow undulations of an average period of 16,5s; the fourth vibration having the max. 2a of 0,25 mm. Then followed quicker waves whose max. 2a was 0,2 mm and whose average period was 11,6s. In the earlier part of this epoch there were also traces of small quick movements.

P.O. P.O. became strong from about 9 p.m. (Oct. 4th), the maximum motion being 0,05 mm in each component. The average period, measured 13h after the commencement of the earthquake, was 6,7s.

Eqke No. 211. October 5th 1899; 5h 24m 49s a.m.

The diagram showed traces of a small earthquake at some distance, obscured by strong P.O. The max. 2a was about 0,05 mm in each component.

Eqke No. 217. October 14th 1899; 0h 38m 5s a.m.

Total duration = 1h 39m.

(NS component).

The 1st P.T. lasted 4m 25s and had an average period of 7,4s, there being also traces of small vibrations of an average period of 4,0s. The max. 2a was 0,07 mm.

The 2nd P.T. lasted 4m 12s. The principal average period was 10,8s, and the max. 2a was 0,14 mm.

The P.P. lasted about 7m. During the first 2m 41s, the average period was 20s, the max. 2a being 0,14 mm. The subsequent vibrations had an average period of 13,0s.

The E.P. The average period deduced from two successive groups of 50 vibrations was as follows:—

10,4s	}	(mean)
10,0		10,2s.

(EW component).

The 1st P.T. lasted 4m 20s. The principal average period was 7,4s, and the max. 2a was 0,03 mm.

The P.P. lasted about 22m, (Here the 2nd P.T. was not well defined.) The average period was 9,5s and the max. 2a 0,1 mm.

The E.P. The average period, measured 1h after the beginning of the earthquake, was 9,2s.

Eqke No. 218. October 14th 1899; 2h 55m 24s a.m.

Total duration=2h 15m.

(NS component).

The 1st P.T. lasted 4m 37s. The max. 2a was 0,12 mm and the average period 7,2s.

The 2nd P.T. lasted 4m 20s. The max. 2a was 0,15 mm and the average period 9,6s. Towards the end there were traces of slow undulations.

The P.P. lasted about 7m 40s. During the first 3m 13s, the average period was about 18s (?), the max. 2a being 0,2 mm. The subsequent portion had an average period of 11,8s.

The E.P. The average period, deduced from seven successive groups of 50 vibrations, was as follows:—

9,5s	(at the commencement)	}	(General mean)
10,4			
9,9			
10,1			
10,1			
10,3			
10,5	(towards the end)		
			10.1s.

(EW component).

The 1st P.T. lasted 4m 35s. The max. 2a was 0,1 mm and the principal average period 6,6s. Towards the end there were traces of vibrations with an average period of 11,0s.

The 2nd P.T. lasted 4m 40s. The max. 2a was 0,15 mm and the average period 8,6s.

The P.P. The motion was most active during the first 4m 20s, the max. 2a being 0,21 mm and the average period 13,0s. Thereafter the movements became regular.

The E.P. The average period, deduced from seven successive groups of 50 vibrations, was as follows :—

10,2s	(at the commencement)	}	(General mean)
10,0			
10,3			
10,5			
10,7			
9,0			
10,0	(towards the end)		
			10,1s.

Eqke No. 219. October 17th 1899 ; 5h 32m 56s p.m.

The diagram showed only traces of very small movements. The following observations at the Meteorological Observatories of Matsuyama and Fukushima probably refer to the same earthquake.

Matsuyama	.. ..	5h 31m 26s p.m.	.. ..	.. ..	Slight.
Fukushima	.. ..	5, 32, 12.	.. ..	.. ..	„

Eqke No. 220. October 19th 1899 ; 6h 28m 59s p.m.

Total duration = 2h.

This was a large earthquake at a great distance.

(EW component).

The 1st P.T. whose duration was 6m 16s consisted of vibrations of an average period of 9,4s, superposed with smaller ones of an average period of 5,2s. The max. 2a of 0,2 mm occurred at 1m 3s from the com-

mencement; this, however, not being a prominent one. The amplitude remained on the whole nearly constant.

The 2nd P.T., whose duration was 4m 15s, consisted of well defined vibrations with an average period of 9,5s, superposed with smaller ones of an average period of 6,4s. The max. 2a was 0,38 mm. There were also some irregular traces of slow undulations.

The P.P. lasted for 15m 50s and began with a slow undulation whose 2a was 0,93 mm and whose period was 38,5s. This was followed by two large vibrations of an average period of 26,3s, whose 2a was 1,75 mm, these two waves forming the most active part of the motion. For the next 14m 20s, the motion was much smaller and had an average period of 16,5s, there being also here and there traces of smaller vibrations. The 2nd max. 2a of 0,9 mm occurred at 4m 47s from the commencement.

The E.P. The average period, deduced from six successive groups of 50 vibrations, was as follows:—

10,4s	(at the commencement)	}	(General mean)
10,2			
9,4			
9,9			
10,5			
10,3	(near the end)		
			10,1s.

(NS component).

The 1st P.T. lasted for 6m 24s. The very first displacement was 0,1 mm towards S, the counter displacement being 0,2 mm towards N. The 3rd vibration had the max. (abs.) 2a of 0,25 mm, the motion thence decreasing.—For the first 1m 28s, the average period was 8,8s. Then the motion quickened, the average period being 5,0s. From about the middle of this epoch, the average period became again slower and equal to 8,2s.

The 2nd P.T., whose duration was 4m 31s, began with the maximum 2a of 0,65 mm, thence gradually diminishing. The average period of the

principal vibrations was 8,7s, there being also traces of slower as well as quicker waves.

The P.P. began with slow undulations of an average period of 10,0s, the initial displacement being 0,5 mm. From 5m 0s after the commencement of this epoch, there appeared the proper oscillations of the pendulum, gradually swelling up to a maximum motion of 5,5 mm and then again gradually settling down. These together occupied 2m 50s, comprising 10 vibrations. For the next 15m 45s the motion consisted of well defined vibrations of an average period of 14,2s.

Eqke No. 222. October 24th 1899; 1h 3m 29s p.m.

Total duration = 2h 36m.

This was a large earthquake at a great distance.

(NS component).

The 1st P.T. whose duration was 2m 30s consisted of slow undulations of an average period of 11,5s, superposed with small vibrations of an average period of 3s. The max. 2a was 0,07 mm.

The 2nd P.T. whose duration was 3m 25s consisted of well defined vibrations of an average period of 8,5s; the max. 2a of 0,22 mm occurring at the commencement.

The P.P. lasted for about 8m 22s. For the first 2m 40s the motion had nearly the same period as in the 2nd P.T., but the amplitude was increased, the max. 2a being 0,36 mm. There were also some doubtful traces of slow undulations of an average period of about 29s. Then appeared a displacement of 0,6 mm, and the motion during the next 3m 21s remained nearly constant in amplitude, consisting of waves of an average period of 7,4s superposed on slow undulations of an average period of 16,8s. Then, for the next 6m 0s, the amplitude was large, the average period being 17,5s. For the next 2m 21s the average period was 17,6s. The motion was probably a result of the composition of the motion of the ground with the proper oscillations of the pendulum, the amplitude reaching gradually the max. 2a of 2,25 mm and then again gradually subsiding.

(EW component).

The P.T. lasted for about 3m 45s.

The P.P. lasted for about 10m. For the first 3m 55s the motion consisted of slow undulations of an average period of 13s, whose (abs.) max. 2a was 0,04 mm. For the next 6m 15s the vibrations became quicker, the average period being 9,4s.

The E.P. The average period, measured near the end, was 10,6s.

(NS component).

The max. 2a was 0,04 mm.

Eqke No. 234. November 23rd 1899; 6h 52m 39s p.m.

Total duration = 4h.

The was an extremely great earthquake at a comparatively near distance, and has been recorded by the A (EW component) and B (NS component) instruments as well as by the newly erected large standard horizontal pendulum apparatus C (EW component). The duration of the P.T., measured from the diagrams of these three apparatus was as follows:—

(A) (EW)	3m 13s	} (mean) 3m 32s.
(B) (NS)	4. 8	
(C) (EW)	3. 15	

In consequence of the great activity of motion, the pendulums of the usual two apparatus (A) and (B) were, soon after the commencement, thrown into strong proper oscillations. The apparatus C, however, has recorded the motion satisfactorily, as its period was much longer than the undulation period of the ground. I shall give therefore only the detailed description of the diagram obtained from the apparatus C.

C (EW component).

The P.T. consisted of vibrations of an average period of 7,6s, superposed in the earlier portion with smaller ones of an average period of 2,1s.

The P.P. lasted for about 1h and began with a well defined prominent slow undulation, whose period was 31s and whose displacements were as follows:—

(first motion) 2,7 mm towards W,
 (counter „) 2,5 „ „ E.

This introductory motion was followed by five quicker waves of an average period of 16s, which together occupied 1m 20s. The 3rd vibration of the series, or the 4th counted from the commencement was the conspicuous (abs.) maximum, its 2a being 6,3 mm and period 16s. This group of the most active movements was followed by five vibrations of an average period of 11,2s, which together occupied 56s.—There were probably a succession of shocks at the earthquake origin, the motion consisting of a great number of alternations of large and small, as well as of slow and quick movements.

The average period. During the first 29m of the P.P. the predominating waves had an average period of 16,2s, superposed here and there with quick small vibrations of an average period of 8,2s. Then waves with shorter period predominated; slow undulations of period from 21s to 28s occurring, however, at intervals. The average period deduced from thirteen series of the successive groups of 50 vibrations, commencing at about 30m after the beginning of the P.P., was as follows:—

9,3s	}	(General mean)
9,1		
9,4		
9,6		
8,7		
9,3		
9,4		
9,3		
9,0		
9,7		
9,8		
9,1		
9,5		

9,3s.

This earthquake was also observed with ordinary seismographs of the Gray-Milne type at the following four Meteorological Observatories :—

Nemuro	6h 51m 30s p.m.	.. .. .	Slight.
Fukushima	6. 54. 3	.. .. .	„
Mito	6. 55. 30	.. .. .	„
Tokyo	6. 53. 19	.. .. .	„

Comparing the times of occurrence at these four observatories with that obtained from the horizontal pendulum diagram at the Seismological Institute, namely 6h 52m 39s, it will be seen that the ordinary seismographs have recorded the quick-period part at the commencement of the earthquake. It is to be noted that the four places of observation are all situated along or near the Pacific coast of Japan.

Eqke No. 235. November 24th 1899; 7h 2m 1s p.m.

Total duration=2h.

(EW component).

The P.T. lasted 4m 25s. The max. 2a was 0,05 mm and the average period 7,2s.

The P.P. lasted about 28m. During the first 19m the motion remained nearly constant in amplitude (max. 2a=0,55 mm), the principal average period being 14,8s. There were also vibrations of an average period of 9,3s.

The E.P. The motion consisted of regular vibrations, whose average period deduced from five successive groups of 50 vibrations was as follows :—

8,9s	} (General mean)
8,5	
8,6	
9,6	
9,2	
	9,0s.

(NS component).

The 1st P.T. lasted 5m 16s. The max. 2a was 0,05 mm and the average period 8,1s.

The 2nd P.T. lasted 4m 21s. The max. 2a was 0,9 mm and the average period 16,3s.

The P.P. lasted 19m. The motion was especially large during the first 8m 15s, which comprised two separate groups of waves of an average period of 16,5s their max. 2a being respectively 3,9 mm and 3,0 mm. In each of these groups the motion gradually swelled up to a maximum and thence again gradually decreased, owing probably to the synchronism of the pendulum oscillations with the shaking of the ground.

The E.P. The average period deduced from three successive groups of 50 vibrations, taken at 1h after the commencement of the earthquake, was as follows:—

$$\left. \begin{array}{l} 9,7s \\ 9,1 \\ 9,5 \end{array} \right\} \begin{array}{l} \text{(General mean)} \\ 9,4s. \end{array}$$

Eqke No. 238. December 4th 1899; 9h 32m 1s a.m.

Total duration=about 40m.

This was a small earthquake at some distance.

(NS component).

The P.T. lasted for about 3½m. But the commencement was doubtful. The motion seemed to consist of slow undulations.

The P.P. For the first 4m, the motion was active and consisted of vibrations of an average period of 8,5s, whose max. 2a of 0,05 mm occurred at about 2m from the commencement.

(EW component).

The P.T. lasted for 5m 40s, the motion beginning with small quick vibrations. (In this component the commencement was definite.)

The P.P. had an average period of 8,1s, the max. 2a of 0,05 mm occurring at 1½m from the commencement.

The following observation at the Ōshima Meteorological Observatory probably refers to the same earthquake:—

Ōshima (Liu Kiu) 9h 28m 36s a.m. Slight.

Eqke No. 243. December 24th 1899; 8h 52m 35s p.m.

Total duration was greater than 10m.

(NS component).

The commencement was uncertain on account of strong P.O. The larger movements lasted for 8m, the average period being 15,8s. The max. 2a was 0,15 mm.

(EW component).

The diagram was obscured by the superposition of lines.

Eqke No. 244. December 25th 1899; 6h 8m 45s a.m.

There were certain doubtful traces of small slow undulations. The diagram was, however, confused by strong P.O.

Eqke No. 245. December 28th 1899; 3h 34m 34s a.m.

Total duration = 25m.

This was a small earthquake at some distance.

The P.T. whose duration was 1m 7s consisted of very small and quick vibrations.

The P.P. lasted for about 6¼m. For the first 1m 31s the motion was comparatively small, the average period being 3,3s and the max. 2a 0,14 mm in each component. Then appeared slower and well defined waves of an average period of 5,9s, whose amplitude did not much vary during 4m 40s. The max. (abs.) 2a was 0,26 mm in each component and occurred at the middle of this epoch.

The E.P. The average period was 5,6s.

P.O. There were very slight traces of P.O., whose average period was 4,3s.
