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HORIZONTAL PENDULUM OBSERVATION OF EARTHQUAKES AT HITOTSUBASHI (TŌKYŌ), 1900.

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Horizontal Pendulum Observations of Earthquakes at Hitotsubashi (Tokyo), 1900.*

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I. Introduction.

§ 1. The following pages contain the results of analysis of the EW component diagrams of 385 earthquakes, which were observed in 1900 at the Seismological Observatory of Hitotsubashi (Tōkyō) with my horizontal pendulum apparatus of portable form, whose magnification was 8 and whose natural period of oscillation was 31,1 sec. The earthquakes, of which only 50 were macro-seismic disturbances and all the rest were *unfelt* ones, are, for the sake of convenience, divided into the following nine groups.

Group I.—Distant Earthquakes. (84 earthquakes).

Group II.—Earthquakes, which originated off the south-eastern coast of Hokkaido. (8 earthquakes).

Group III.—Earthquakes, which originated off the north-eastern coast of the Main Island. (23 earthquakes).

Group IV.—Earthquakes, which originated off the eastern coast of the Kazusa-Awa Peninsula. (19 earthquakes).

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* For the earthquake observations in 1898-1899 at Tōkyō (Hongō), the reader is referred to the *Publications*, Nos. 5 and 6.

Group V.—Earthquakes, which originated under the sea in the vicinity of the Izu Islands. (47 earthquakes).

Group VI.—Earthquakes, which originated in western Japan. (3 earthquakes).

Group VII.—Earthquakes, which originated in central Japan. (5 earthquakes).

Group VIII, A.—Local earthquakes recorded at one or more places. (73 earthquakes).

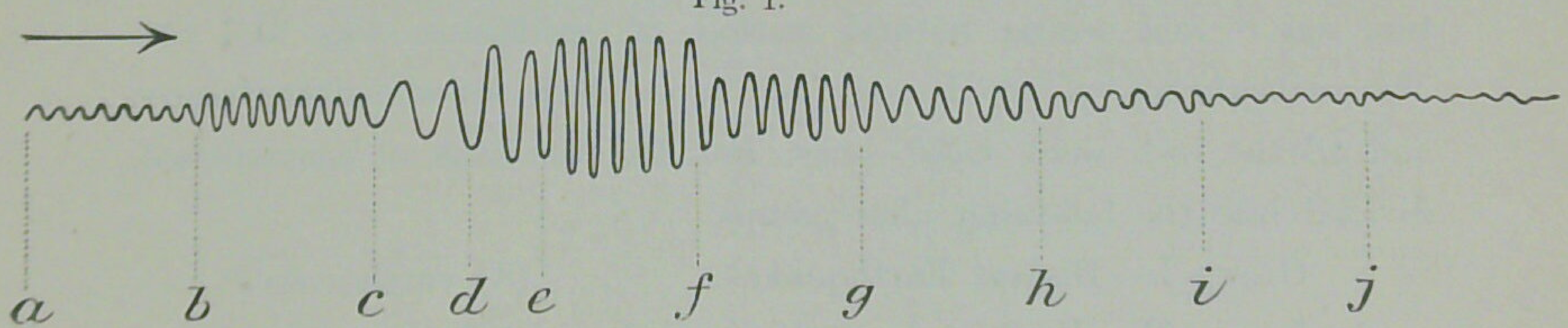
Group VIII, B.—Local unfelt earthquakes, nowhere recorded by Gray-Milne seismographs. (118 earthquakes).

Group IX.—Earthquakes of miscellaneous origins. (5 earthquakes).

The above division of the earthquakes into nine groups is nearly similar to the classification employed in the cases of the earthquakes observed in 1898-1899 (the *Publications*, Nos. 5 and 6).

§ 2. *Character of motion in distant earthquakes.* A careful examination of the seismograms shows that the earthquake motion consists generally of a series of different epochs, in each of which the period* remains essentially constant, while the amplitude is also on the whole constant, except for the occurrence of maximum and minimum groups.

Fig. 1.



a b......1st Prel. Tremor.
b c......2nd „ „
c d e f..j..Principal Portion. ....
j..... End Portion.

c d......1st Phase of princ. portion.
d e......2nd „ „ „
e f......3rd „ „ „
f g......4th „ „ „
etc.

The successive epochs of the earthquake motion, illustrated in Fig. 1, are as follows.

The *preliminary tremor*, which consists principally of vibrations

* The term *period* is used in the sense of the *complete period*.

of small amplitude and of comparatively short period, is divided into the earlier portion or the *first preliminary tremor*, and the later portion or the *second preliminary* tremor. Commencement of the latter is marked by an increase of the amplitude and, in many cases, also by the appearance of slow undulations.

The *principal portion** denotes the most active part of an earthquake, which follows the preliminary tremors and consists of movements of larger amplitude. The earlier part of the *principal portion* is further subdivided into three successive stages as follows:—(*a*) The *1st phase*, consisting of a few very slow undulations; (*b*) the *2nd phase*, consisting of slow undulations, whose period is generally somewhat shorter than in the 1st phase; (*c*) the *3rd phase*, consisting of vibrations of period much quicker than that in the preceding two phases. The 3rd phase is followed by others of smaller amplitude (*fg*, *gh*, etc.), which may be termed respectively the 4th, 5th, 6th,.. phases of the principal portion.

Lastly, the *end portion* denotes the feeble finishing part of the earthquake motion, which follows the principal portion.

In earthquakes of near origin, the motion is, on account of the existence of quick vibrations of macro-seismic character, much more complex than in distant earthquakes, it being generally difficult to subdivide the principal portion into the different phases.

§ 3. *Analysis of the seismograms.* The seismograms have been analysed on the supposition that the waves recorded are *horizontal movements*, and not the effects due to the tilting of the ground; that is to say, the range of motion or double amplitude, denoted by 2a, has been obtained in each case by dividing the actual trace on the seismogram by the multiplication ratio of the pointer of the instrument. (See the *Publications*, No. 5.)

In the following pages, the terms *waves*, *vibrations*, and *undulations* are used all in the sense of periodic movements, with the follow-

* The *principal portion* is used here in a sense slightly more extensive than that defined in the *Publications*, No. 5.

ing distinction: *vibrations* denote waves of quicker period, while *undulations* denote those of slower period.

II. Results of the observations at Hitotsubashi.

§ 4. The results of the horizontal pendulum observations of the 385 earthquakes are contained in Tables I—XI; namely, Table I gives the list of the earthquakes, while Tables II, III, IV, V, VI, VII, VIII, IX, X, and XI give, respectively for the earthquakes of Groups I, II, III, IV, V, VI, VII, VIII A, VIII B, and IX, some or all of the following elements of motion:—

Date and time of occurrence;

Total duration;

Durations of the 1st and 2nd preliminary tremors and of the principal portion;

Average period of waves in the 1st and 2nd preliminary tremors and in the different portions of the principal portion.

Maximum range of motion, or double amplitude (2a) in the 1st and 2nd preliminary tremors and in the different portions of the principal portion.

Abbreviations. The abbreviations used in the tables are as follows:—

P. T.............Preliminary tremor,
1st P. T.......1st preliminary tremor,
2nd P. T.......2nd ,, ,,
P. P.............Principal portion,
E. P.............End portion,
2a ....Double amplitude, or range of motion.

For the sake of reference, I give in Table XII a list of the earthquakes observed in 1900 by the Gray-Milne seismograph at the Central Meteorological Observatory, Tōkyō.

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

TABLE I.

LIST OF 385 EARTHQUAKES OBSERVED IN 1900 AT HITOTSUBASHI, TŌKYŌ, WITH OMORI'S HORIZONTAL PENDULUM APPARATUS.

1900.

No.	Group.	Date.		Time of occurrence.*				Total duration.		
				h	m	s		h	m	s
1	I	Jan.	1	5.	32.	11	a.m.	0.	20.	00
2	I	,,	6	4.	6.	24	,,	2.	30.	00
3	I	,,	11	5.	58.	23	p.m.	1.	00.	00
4	IX	,,	13	1.	20.	26	a.m.	0.	11.	00
5	VIII, B	,,	15	10.	32.	12	,,	0.	09.	00
6	VIII, A	,,	,,	0.	33.	07	p.m.	0.	05.	30
7	VII	,,	17	0.	13.	36	a.m.	0.	14.	00
8	III	,,	,,	5.	31.	45	,,	0.	13.	00
9	I	,,	,,	3.	35.	9	p.m.	0.	35.	00
10	I	,,	18	2.	7.	39	,,	0.	42.	00
11	V	,,	,,	4.	26.	28	,,	0.	02.	35
12	II	,,	,,	4.	44.	44	,,	1.	00.	00
13	I	,,	20	3.	52.	39	,,	2.	53.	00
14	VIII, A	,,	21	6.	27.	14	,,	0.	03.	56
15	I	,,	24	4.	19.	44	,,	2.	27.	00
16	VIII, B	,,	27	0.	6.	4	a.m.	0.	01.	38
17	I	,,	30	7.	56.	48	,,	0.	35.	00
18	IV	,,	31	2.	37.	51	,,	0.	06.	00
19	I	,,	,,	11.	23.	29	p.m.	0.	24.	00
20	II	Feb.	1	4.	21.	7	a.m.	1.	30.	00
21	VI	,,	2	5.	4.	26	p.m.	0.	00.	55
22	I	,,	3	1.	28.	44	,,	0.	48.	00
23	VIII, A	,,	,,	7.	9.	55	,,	0.	04.	50
24	I	,,	5	7.	20.	19	,,	1.	09.	00
25	VIII, A	,,	9	6.	38.	48	a.m.	0.	03.	26
26	VIII, B	,,	,,	3.	13.	59	p.m.	0.	01.	09
27	VIII, B	,,	12	7.	37.	43	a.m.	0.	02.	45
28	II	,,	13	1.	27.	40	p.m.	1.	26.	00
29	VIII, B	,,	,,	2.	26.	16	,,	0.	00.	53
30	I	,,	,,	3.	38.	17	,,	2.	17.	00

* The time is given in the *1st Normal Japan Time*, or that of *long.* 135° E.

1900.

No.	Group.	Date.		Time of occurrence.				Total duration.		
				h	m	s		h	m	s
31	VIII, B	Feb.	13	6.	16.	31	p.m.	0.	00.	57
32	VIII, B	,,	,,	7.	53.	36	,,	0.	01.	22
33	VIII, B	,,	,,	9.	46.	42	,,	0.	01.	35
34	VIII, B	,,	14	10.	44.	20	a.m.	0.	00.	54
35	I	,,	,,	6.	31.	43	p.m.	1.	18.	00
36	VIII, B	,,	,,	9.	34.	14	,,	0.	00.	34
37	IV	,,	16	10.	50.	27	a.m.	0.	06.	20
38	VIII, A	,,	,,	4.	35.	00	p.m.	0.	02.	24
39	VIII, A	,,	17	0.	52.	32	,,	0.	03.	40
40	VIII, A	,,	18	2.	46.	54	a.m.	0.	02.	38
41	VIII, A	,,	,,	8.	03.	43	,,	0.	03.	02
42	VIII, A	,,	20	11.	50.	42	p.m.	0.	02.	55
43	II	,,	24	9.	20.	07	,,	0.	43.	00
44	I	,,	26	7.	19.	30	a.m.	0.	34.	00
45	III	,,	,,	11.	34.	16	,,	0.	8.	20
46	VIII, A	March	1	7.	32.	14	,,	0.	02.	28
47	VIII, A	,,	,,	10.	08.	11	p.m.	0.	03.	10
48	VIII, B	,,	3	1.	47.	58	,,	0.	01.	18
49	VIII, B	,,	,,	4.	27.	33	,,	0.	02.	50
50	VIII, A	,,	4	11.	58.	9	a.m.	0.	12.	00
51	VIII, B	,,	,,	3.	18.	5	p.m.	0.	01.	30
52	I	,,	,,	3.	43.	40	,,	0.	14.	00
53	IV	,,	,,	4.	45.	32	,,	0.	06.	20
54	IV	,,	7	7.	15.	53	,,	0.	03.	06
55	VIII, B	,,	9	10.	57.	52	a.m.	0.	03.	38
56	I	,,	,,	11.	29.	17	,,	2.	04.	00
57	VIII, A	,,	,,	6.	01.	11	p.m.	0.	05.	50
58	VIII, B	,,	12	9.	51.	58	a.m.	0.	04.	00
59	III	,,	,,	10.	35.	01	,,	1.	19.	20
60	IV	,,	,,	1.	41.	15	p.m.	0.	10.	00

1900.

No.	Group.	Date.		Time of occurrence.				Total duration.		
				h	m	s		h	m	s
61	II	March	12	7.	55.	53	p.m.	0.	12.	00
62	III	,,	13	1.	09.	38	a.m.	0.	10.	00
63	I	,,	14	5.	24.	41	p.m.	2.	00.	00
64	IV	,,	,,	11.	56.	04	,,	0.	07.	35
65	VIII, A	,,	15	6.	23.	40	,,	0.	04.	13
66	VIII, A	,,	16	10.	02.	22	,,	0.	08.	30
67	III	,,	17	1.	37.	45	,,	0.	18.	40
68	VIII, B	,,	18	6.	17.	32	,,	0.	05.	20
69	VII	,,	22	0.	56.	07	a.m.	0.	17.	50
70	VIII, A	,,	26	5.	32.	34	p.m.	0.	17.	40
71	VIII, A	,,	,,	8.	54.	33	,,	0.	09.	40
72	VIII, B	,,	,,	9.	40.	05	,,	0.	02.	52
73	I	,,	28	8.	03.	36	,,	0.	12.	00
74	I	,,	29	2.	06.	15	,,	0.	46.	00
75	IX	,,	,,	4.	38.	52	,,	0.	04.	21
76	I	April	1	3.	51.	37	,,	0.	47.	00
77	VIII, A	,,	15	7.	51.	27	a.m.	0.	14.	20
78	III	,,	16	7.	13.	35	p.m.	0.	08.	04
79	IV	,,	18	2.	14.	30	,,	0.	02.	24
80	VIII, A	,,	20	9.	08.	05	,,	0.	03.	14
81	VIII, B	,,	22	11.	36.	45	a.m.	0.	02.	51
82	VIII, B	,,	,,	0.	52.	49	p.m.	0.	01.	21
83	VIII, B	,,	,,	2.	13.	39	,,	0.	02.	30
84	VIII, B	,,	,,	5.	43.	48	,,	0.	00.	47
85	IX	,,	25	8.	18.	52	a.m.	} 2.	22.	00
86	IX	,,	,,	8.	23.	02	,,			
87	VIII, A	,,	,,	0.	19.	28	p.m.	0.	02.	36
88	VIII, B	,,	27	8.	12.	46	a.m.	0.	02.	03
89	VIII, B	,,	,,	9.	23.	22	,,	0.	00.	22
90	VIII, B	,,	,,	11.	18.	42	,,	0.	01.	47

1900.

No.	Group.	Date.		Time of occurrence.				Total duration.		
				h	m	s		h	m	s
91	VIII, B	April	27	0.	10.	16	p.m.	0.	03.	35
92	I	,,	,,	4.	02.	59	,,	0.	11.	00
93	VIII, B	,,	28	2.	12.	08	,,	0.	00.	32
94	VIII, B	,,	,,	3.	16.	39	,,	0.	00.	28
95	VIII, B	,,	,,	6.	24.	12	,,		——	
96	VIII, B	,,	,,	7.	07.	26	,,	0.	00.	48
97	I	May	1	4.	47.	41	a.m.	0.	27.	00
98	I	,,	3	11.	36.	20	,,	0.	21.	00
99	VIII, A	,,	5	9.	16.	10	,,	0.	03.	42
100	VIII, B	,,	,,	11.	45.	16	p.m.	0.	06.	20
101	III	,,	12	3.	23.	18	a.m.	2.	00.	00
102	VIII, B	,,	,,	9.	47.	50	,,	0.	01.	43
103	III	,,	,,	11.	44.	36	,,	0.	08.	20
104	VIII, B	,,	,,	5.	37.	47	p.m.	0.	01.	04
105	III	,,	14	4.	49.	44	a.m.	0.	04.	05
106	VIII, A	,,	15	7.	12.	50	,,	0.	13.	00
107	VIII, A	,,	,,	9.	04.	0	p.m.	0.	04.	10
108	VIII, B	,,	16	10.	43.	42	,,		——	
109	I	,,	18	1.	05.	37	,,	1.	14.	00
110	I	,,	19	11.	48.	57	,,	0.	23.	00
111	VIII, A	,,	21	8.	27.	26	a.m.	0.	05.	30
112	IV	,,	,,	10.	47.	53	p.m.	0.	06.	35
113	IX	,,	24	0.	11.	17	a.m.	0.	19.	20
114	I	,,	,,	5.	16.	53	p.m.	0.	30.	00
115	VIII, B	,,	27	1.	59.	50	a.m.	0.	05.	00
116	I	,,	,,	10.	19.	35	,,	0.	14.	00
117	I	,,	30	1.	49.	57	p.m.	0.	10.	00
118	III	,,	31	1.	20.	07	a.m.	0.	17.	40
119	VIII, A	,,	,,	5.	39.	58	,,	0.	10.	10
120	VII	,,	,,	5.	45.	17	p.m.	0.	08.	25

1900.

No.	Group.	Date.		Time of occurrence.				Total duration.		
				h	m	s		h	m	s
121	III	June	2	9.	07.	29	a.m.	0.	24.	50
122	I	,,	3	6.	38.	53	,,	2.	00.	00
123	VIII, B	,,	7	1.	50.	43	,,	0.	01.	30
124	II	,,	8	5.	26.	58	p.m.	0.	10.	00
125	VIII, A	,,	,,	8.	30.	56	,,	0.	04.	00
126	VI	,,	9	9.	12.	45	,,	0.	01.	17
127	I	,,	10	4.	24.	44	,,	0.	16.	00
128	VIII, A	,,	,,	7.	29.	19	,,	0.	03.	20
129	I	,,	10	7.	52.	02	p.m.	0.	48.	00
130	I	,,	13	5.	58.	36	a.m.	2.	10.	00
131	VIII, A	,,	,,	1.	42.	51	p.m.	8.	00.	15
132	VIII, B	,,	,,	1.	56.	09	,,		—	
133	VIII, B	,,	,,	3.	05.	20	,,	0.	00.	27
134	VIII, B	,,	,,	4.	42.	59	,,	0.	01.	00
135	VIII, A	,,	20	4.	31.	30	,,	0.	02.	30
136	I	,,	22	6.	11.	09	a.m.	12.	00.	00
137	I	,,	23	4.	38.	51	p.m.	1.	36.	00
138	IV	,,	24	3.	59.	40	,,	0.	05.	24
139	VIII, B	,,	25	7.	55.	26	a.m.	0.	07.	05
140	VIII, B	,,	,,	9.	24.	03	,,	0.	11.	20
141	VIII, B	,,	,,	9.	44.	33	,,	0.	02.	41
142	VIII, B	,,	,,	10.	14.	49	,,	0.	00.	24
143	VIII, B	,,	,,	10.	20.	33	,,	0.	00.	55
144	VIII, B	,,	,,	11.	56.	09	,,	0.	13.	05
145	VIII, B	,,	,,	3.	47.	04	p.m.	0.	09.	10
146	VIII, B	,,	,,	4.	09.	02	,,	0.	01.	07
147	VIII, B	,,	,,	4.	53.	37	,,	0.	01.	26
148	VIII, B	,,	,,	4.	54.	29	,,	0.	05.	40
149	VIII, B	,,	,,	5.	25.	31	,,	0.	02.	37
150	VIII, B	,,	,,	5.	46.	43	,,	0.	00.	18

1900.

No.	Group.	Date.		Time of occurrence.				Total duration.		
				h	m	s		h	m	s
151	VIII, B	June	25	6.	09.	27	p.m.	0.	01.	30
152	IV	,,	,,	9.	12.	08	a.m.		(Short)	
153	IV	,,	,,	10.	31.	11	,,	0.	03.	06
154	IV	,,	,,	10.	28.	42	p.m.		(Short)	
155	IV	,,	26	5.	09.	46	a.m.		Do.	
156	VIII, B	,,	,,	5.	24.	03	,,		Do.	
157	VIII, B	,,	,,	6.	25.	53	,,		——	
158	VIII, B	,,	,,	10.	56.	27	,,	0.	06.	00
159	I	,,	,,	2.	44.	38	p.m.	1.	30.	00
160	IV	,,	,,	6.	57.	53	,,	0.	21.	20
161	IV	,,	,,	9.	17.	46	,,	0.	02.	10
162	VIII, B	,,	,,	9.	21.	31	,,	0.	00.	27
163	VIII, A	,,	,,	9.	48.	35	,,	0.	04.	45
164	VIII, A	,,	,,	10.	15.	09	,,	0.	02.	39
165	VIII, A	,,	,,	10.	19.	43	,,	0.	03.	12
166	VIII, A	,,	27	0.	53.	39	a.m.	0.	01.	49
167	VIII, B	,,	,,	0.	40.	33	p.m.	0.	02.	56
168	VIII, B	,,	,,	0.	2.		,,	0.	02.	27
169	I	,,	28	6.	04.	15	a.m.	0.	12.	00
170	III	,,	30	2.	51.	25	p.m.	0.	05.	40
171	I	July	2	10.	47.	36	a.m.	0.	24.	80
172	VIII, A	,,	,,	5.	38.	27	p.m.	0.	12.	55
173	VIII, B	,,	3	6.	16.	48	a.m.	0.	04.	56
174	VIII, B	,,	5	3.	19.	33	p.m.	0.	03.	20
175	VIII, B	,,	,,	4.	25.	21	,,	0.	01.	47
176	VIII, B	,,	8		——		a.m.	0.	01.	27
177	VIII, A	,,	,,	11.	47.	38	,,	0.	19.	10
178	VIII, B	,,	10	9.	39.	41	,,	0.	00.	50
179	VIII, B	,,	,,	10.	57.	51	p.m.	0.	02.	54
180	VIII, A	,,	,,	11.	45.	25	,,	0.	09.	10

1900.

No.	Group.	Date.		Time of occurrence.				Total duration.		
				h	m	s		h	m	s
181	VIII, B	July	13	4.	02.	07	p.m.	0.	03.	14
182	VIII, B	,,	,,	5.	39.	24	,,	0.	03.	23
183	VIII, B	,,	,,	6.	41.	02	,,	0.	01.	37
184	VIII, A	,,	,,	7.	19.	53	,,	0.	03.	44
185	VIII, B	,,	,,	7.	23.	23	,,	0.	03.	05
186	VIII, B	,,	,,	7.	38.	08	,,	0.	01.	50
187	VIII, A	,,	,,	10.	21.	26	,,	0.	02.	21
188	VIII, A	,,	14	7.	19.	05	a.m.	0.	02.	19
189	I	,,	,,	——			,,	0.	08.	00
190	VIII, A	,,	,,	8.	11.	37	,,	0.	04.	00
191	VIII, A	,,	,,	8.	24.	17	,,	0.	04.	33
192	VIII, B	,,	,,	8.	40.	23	,,	0.	02.	05
193	VIII, B	,,	,,	1.	58.	05	p.m.	0.	01.	42
194	VIII, B	,,	,,	2.	44.	50	,,	0.	01.	09
195	VIII, B	,,	,,	3.	04.	35	,,	0.	02.	19
196	VIII, B	,,	,,	3.	51.	10	,,	0.	00.	55
197	VIII, B	,,	,,	5.	24.	50	,,	0.	01.	19
198	VIII, B	,,	,,	5.	27.	06	,,	0.	01.	44
199	VIII, B	,,	,,	10.	23.	28	,,	0.	01.	00
200	VIII, B	,,	15	2.	13.	13	a.m.	0.	05.	30
201	I	,,	,,	11.	09.	39	,,	0.	12.	00
202	VIII, B	,,	16	9.	27.	54	,,		(Short.)	
203	VIII, B	,,	,,	9.	41.	15	,,		Do.	
204	VIII, A	,,	,,	5.	32.	37	p.m.	0.	06.	47
205	VIII, B	,,	17	0.	49.	59	,,	0.	10.	00
206	VIII, B	,,	,,	3.	30.	56	,,	0.	02.	20
207	VIII, A	,,	20	4.	34.	35	,,	0.	04.	15
208	V	,,	21	7.	29.	05	a.m.	0.	12.	10
209	I	,,	,,	3.	52.	07	p.m.	2.	05.	00
210	VIII, B	,,	24	1.	33.	10	,,	0.	00.	58

1900.

No.	Group.	Date.	Time of occurrence.	Total duration.
			h m s	h m s
211	VIII, B	July 24	9. 32. 24 p.m.	0. 00. 58
212	VIII, A	,, ,,	9. 52. 27 ,,	0. 03. 49
213	I	,, ,,	10. 01. 45 ,,	0. 25. 00
214	I	,, 25	2. 07. 06 a.m.	0. 36. 00
215	VIII, B	,, ,,	9. 0. 44 ,,	(Short.)
216	VIII, B	,, ,,	10. 0. 31 ,,	(Do.)
217	VIII, B	,, 26	7. 34. 26 ,,	0. 09. 20
218	I	,, 29	4. 08. 42 p.m.	4. 00. 00
219	I	Aug. 1	8. 54. 41 a.m.	0. 19. 00
220	I	,, ,,	3. 11. 35 p.m.	0. 56. 00
221	I	,, ,,	5. 11. 12 ,,	1. 30. 00
222	I	,, 2	1. 33. 21 ,,	0. 27. 00
223	VIII, A	,, ,,	3. 42. 41 ,,	0. 01. 00
224	I	,, ,,	3. 59. 25 ,,	0. 11. 00
225	I	,, ,,	6. 34. 23 ,,	0. 24. 00
226	VIII, A	,, ,,	7. 17. 29 ,,	(Short.)
227	I	,, 3	2. 31. 13 ,,	2. 45. 00
228	VIII, B	,, 4	5. 55. 15 a.m.	——
229	IV	,, ,,	1. 33. 40 p.m.	1. 10. 00
230	III	,, 5	1. 21. 17 ,,	3. 45. 00
231	VIII, A	,, 8	7. 15. 04 ,,	0. 03. 04
232	VIII, A	,, 13	1. 19. 07 a.m.	0. 05. 14
233	VIII, A	,, ,,	1. 45. 01 ,,	0. 01. 30
234	VIII, B	,, ,,	2. 16. 40 ,,	0. 01. 45
235	VIII, B	,, ,,	2. 42. 19 ,,	0. 01. 30
236	I	,, ,,	2. 36. 12 p.m.	0. 41. 00
237	I	,, 14	5. 19. 39 a.m.	3. 00. 00
238	I	,, ,,	8. 0. 28 ,,	0. 37. 00
239	VIII, A	,, 17	6. 56. 24 ,,	0. 02. 34
240	IV	,, ,,	5. 26. 58 p.m.	0. 05. 16

1900.

No.	Group.	Date.		Time of occurrence.				Total duration.		
				h	m	s		h	m	s
241	I	Aug.	21	3.	16.	12	a.m.		——	
242	VIII, B	,,	25	11.	38.	52	p.m.	0.	02.	38
243	VIII, B	,,	26	9.	07.	34	,,		——	
244	VIII, A	,,	27	2.	15.	49	a.m.	0.	02.	55
245	VIII, A	,,	,,	2.	59.	52	p.m.	0.	08.	53
246	VIII, A	,,	,,	4.	27.	35	,,	0.	04.	25
247	VIII, A	,,	,,	4.	32.	35	,,	0.	03.	20
248	VIII, B	,,	28	7.	03.	06	,,	0.	01.	15
249	II	,,	29	11.	31.	20	a.m.	2.	48.	00
250	I	,,	,,	3.	14.	09	p.m.	2.	00.	00
251	VIII, B	Sept.	1	11.	16.	18	a.m.	0.	03.	30
252	III	,,	5	6.	02.	29	p.m.	0.	04.	20
253	III	,,	6	2.	20.	15	a.m.	0.	02.	40
254	VIII, B	,,	10	4.	45.	33	p.m.	0.	03.	30
255	I	,,	,,	9.	29.	23	,,	0.	14.	00
256	VIII, A	,,	,,	9.	39.	50	,,	0.	02.	04
257	VI	,,	15	1.	23.	27	,,	0.	00.	24
258	I	,,	,,	8.	51.	27	,,		——	
259	I	,,	18	7.	01.	41	a.m.	2.	30.	00
260	I	,,	,,	9.	48.	41	,,	0.	14.	00
261	VIII, B	,,	19	4.			p.m.	0.	02.	23
262	I	,,	20	4.	11.	0	a.m.	1.	20.	00
263	III	,,	24	0.	35.	22	p.m.	0.	13.	50
264	VIII, B	,,	26	5.	52.	27	,,	0.	01.	31
265	VIII, B	,,	29	2.	38.	14	,,	0.	02.	04
266	I	,,	,,	11.	16.	32	,,	0.	20.	00
267	VIII, B	Oct.	2	2.	14.	29	a.m.	0.	01.	53
268	VII	,,	,,	3.	37.	51	,,	0.	18.	40
269	I	,,	,,	9.	03.	04	p.m.	1.	00.	00
270	IV	,,	3	3.	21.	09	a.m.	0.	09.	42

1900.

No.	Group.	Date.		Time of occurrence.				Total duration		
				h	m	s		h	m	s
271	III	Oct.	3	3.	50.	56	a.m.	0.	07.	35
272	I	,,	8	6.	06.	44	,,	2.	00.	00
273	I	,,	,,	6.	02.	16	p.m.	3.	00.	00
274	I	,,	,,	10.	09.	35	,,		——	
275	VIII, B	,,	,,	11.	42.	49	,,	0.	02.	07
276	VIII, A	,,	9	1.	40.	03	a.m.	0.	02.	08
277	I	,,	,,	9.	37.	14	p.m.	4.	00.	00
278	I	,,	10	0.	35.	45	,,	1.	00.	00
279	IV	,,	,,	2.	0.	56	,,	0.	05.	33
280	VIII, A	,,	11	4.	03.	44	a.m.	0.	04.	48
281	VIII, B	,,	,,	6.	26.	46	p.m.	0.	02.	06
282	VIII, B	,,	12	4.	03.	47	a.m.	0.	05.	00
283	VIII, B	,,	13	8.	01.	38	,,	0.	17.	20
284	III	,,	16	0.	27.	27	p.m.	0.	05.	35
285	VIII, B	,,	,,	8.	38.	29	,,	0.	02.	01
286	I	,,	17	8.	26.	40	,,	0.	47.	00
287	VIII, B	,,	19	11.	48.	31	a.m.	0.	02.	30
288	I	,,	21	3.	35.	11	,,	1.	04.	00
289	VIII, B	,,	26	0.	28.	52	p.m.	0.	09.	34
290	VIII, B	,,	27	2.	58.	45	a.m.	0.	06.	37
291	I	,,	29	6.	29.	32	p.m.	3.	15.	00
292	V	Nov.	1	9.	50.	15	a.m.	0.	24.	00
293	II	,,	2	3.	03.	59	p.m.	0.	15.	00
294	V	,,	5	9.	16.	0	a.m.	0.	13.	00
295	V	,,	,,		——		a.m.		——	
296	V	,,	,,	2.	10.	41	p.m.	0.	34.	10
297	V	,,	,,	2.	47.	57	,,	0.	05.	38
298	V	,,	,,	2.	53.	44	,,	0.	01.	34
299	V	,,	,,	3.	07.	29	,,	0.	03.	53
300	V	,,	,,	4.	14.	58	,,	0.	01.	35

1900.

No.	Group.	Date.		Time of occurrence.				Total duration.		
				h	m	s		h	m	s
301	V	Nov.	5	4.	41.	42	p.m.	(More than 4h.)		
302	V	,,	,,	5.	05.	32	,,	0.	10.	50
303	V	,,	,,	5.	19.	34	,,	0.	30.	00
304	V	,,	,,	6.	39.	22	,,	0.	01.	34
305	V	,,	,,	7.	11.	40	,,	0.	03.	39
306	V	,,	,,	7.	15.	02	,,	0.	02.	08
307	V	,,	,,	7.	17.	26	,,	0.	04.	20
308	V	,,	,,	7.	26.	49	,,	0.	01.	35
309	V	,,	,,	7.	38.	36	,,	0.	15.	50
310	V	,,	,,	7.	55.	18	,,	0.	02.	02
311	V	,,	,,	8.	12.	48	,,	0.	01.	54
312	V	,,	,,	8.	24.	44	,,	0.	02.	46
313	V	,,	,,	8.	52.	57	,,	0.	03.	36
314	V	,,	,,	8.	58.	49	,,	0.	00.	39
315	V	,,	,,	9.	17.	56	,,	0.	13.	50
316	V	,,	,,	9.	35.	46	,,	0.	10.	05
317	V	,,	,,	9.	45.	27	,,	0.	20.	00
318	V	,,	6	0.	42.	19	a.m.	0.	08.	35
319	V	,,	,,	3.	48.	41	,,	0.	01.	36
320	V	,,	,,	1.	49.	59	p.m.	0.	05.	35
321	V	,,	,,	3.	50.	14	,,	0.	04.	50
322	V	,,	,,	3.	58.	38	,,	0.	00.	54
323	V	,,	,,	6.	13.	54	,,	0.	53.	00
324	V	,,	8	2.	57.	47	a.m.	0.	05.	19
325	V	,,	,,	6.	49.	02	p.m.	0.	05.	00
326	V	,,	9	1.	41.	19	a.m.	0.	10.	51
327	V	,,	,,	1.	52.	19	,,	0.	06.	04
328	V	,,	,,	2.	55.	03	,,	(More than 2h.)		
329	V	,,	,,	5.	45.	20	,,	0.	10.	30
330	V	,,	,,	11.	29.	59	,,	0.	20.	20

1900.

No.	Group.	Date.		Time of occurrence. h	m	s		Total duration. h	m	s
331	VIII, A	Nov.	9	10.	32.	21	p.m.	0.	03.	05
332	III	,,	,,	11.	41.	36	,,	0.	01.	33
333	I	,,	10	2.	20.	59	a.m.	1.	30.	00
334	V	,,	,,	5.	27.	07	,,	0.	12.	00
335	V	,,	,,	7.	12.	31	,,	0.	11.	30
336	VIII, A	,,	,,	2.	15.	18	p.m.	0.	01.	59
337	V	,,	,,	8.	01.	35	,,	0.	02.	42
338	VIII, A	,,	11	1.	10.	10	a.m.	0.	03.	01
339	V	,,	,,	3.	46.	29	p.m.	0.	02.	44
340	V	,,	,,	3.	23.	0	a.m.	0.	02.	42
341	I	,,	12	10.	14.	55	,,	1.	23.	00
342	I	,,	13	3.	44	34	,,	0.	20.	00
343	VIII, B	,,	,,	6.	12.	49	,,	0.	01.	45
344	VIII, A	,,	,,	6.	15.	27	,,	0.	02.	49
345	I	,,	,,	6.	18.	03	,,	0.	15.	00
346	I	,,	,,	6.	32.	14	,,	0.	21.	00
347	III	,,	,,	7.	36.	11	,,	1.	14.	00
348	I	,,	14	4.	43.	07	,,	0.	15.	00
349	VIII, B	,,	,,	2.	0.	04	p.m.	0.	11.	40
350	VIII, B	,,	,,	3.	33.	43	,,	0.	00.	57
351	VIII, A	,,	,,	7.	18.	31	,,	0.	04.	12
352	VIII, A	,,	15	3.	13.	25	a.m.		(Short)	
353	VIII, A	,,	,,	3.	16.	56	,,		(Do.)	
354	VIII, B	,,	,,	3.	24.	33	,,	0.	02.	40
355	III	,,	,,	6.	37.	30	,,	0.	34.	10
356	VIII, A	,,	,,	8.	05.	33	,,	0.	04.	23
357	VIII, B	,,	,,	7.	40.	18	p.m.	0.	04.	17
358	VIII, A	,,	,,	10.	53.	35	,,	0.	05.	28
359	VIII, B	,,	16	9.	18.	15	a.m.	0.	04.	23
360	V	,,	,,	9.	32.	53	,,	0.	19.	40

1900.

No.	Group.	Date.	Time of occurrence.	Total duration.
			h m s	h m s
361	VIII, B	Nov. 17	6. 59. 35 a.m.	0. 07. 00
362	VIII, A	,, 19	4. 55. 33 p.m.	0. 03. 41
363	V	,, ,,	10. 58. 39 ,,	0. 19. 40
364	VIII, B	,, 20	9. 24. 34 ,,	0. 05. 00
365	I	,, 24	4. 49. 13 ,,	3. 40. 00
366	VII	,, 27	9. 16. 01 ,,	0. 04. 13
367	VIII, A	,, 28	2. 43. 12 a.m.	0. 01. 00
368	V	Dec. 1	0. 33. 14 p.m.	0. 16. 30
369	III	,, 2	1. 33. 41 a.m.	0. 02. 47
370	VIII, A	,, ,,	5. 27. 37 ,,	0. 02. 28
371	I	,, ,,	7. 59. 56 ,,	0. 38. 00
372	I	,, 3	11. 07. 02 p.m.	2. 00. 00
373	I	,, 4	0. 16. 23 a.m.	0. 13. 00
374	VIII, B	,, ,,	1. 12. 20 ,,	0. 03. 56
375	III	,, 6	2. 01. 21 p.m.	0. 10. 42
376	I	,, 7	4. 13. 05 ,,	2. 00. 00
377	VIII, A	,, 17	0. 59. 35 a.m.	0. 01. 23
378	VIII, A	,, ,,	9. 28. 02 ,,	0. 02. 09
379	I	,, ,,	5. 7. 57 p.m.	0. 30. 00
380	I	,, 19	7. 31. 49 a.m.	1. 35. 00
381	VIII, B	,, ,,	8. 53. 10 ,,	0. 05. 51
382	VIII, A	,, ,,	9. 26. 50 p.m.	0. 03. 50
383	I	,, 25	2. 07. 44 ,,	3. 30. 00
384	VIII, A	,, 29	3. 32. 51 ,,	0. 04. 20
385	VIII, B	,, 30	0. 26. 26 a.m.	0. 01. 24

TABLE II. DISTANT

No.	Date. 1900.	Time of occurrence. (1st. N. J. T.)	Duration of Total eqke.	1st. P. T.	2nd. P. T.	Total P. T.	P. P.
		h m s	h m	m s	m s	m s	m s
1	Jan. 1	5. 32. 11 a.m.	0. 20	—	—	—	—
2	„ 6	4. 6. 24 a.m.	2. 30	7. 27	5. 28	12. 52	24. 00
3	„ 11	5. 58. 23 p.m.	1. 00	—	—	7. 38	21. 00
9	„ 17	3. 35. 9 p.m.	0. 35	—	—	13. 00	8.30
10	„ 18	2. 7. 39 p.m.	0. 42	7. 25	7. 40	15. 05	—
13	„ 20	3. 52. 39 p.m.	2. 53	10. 40	11. 00	21. 40	90. 00
15	„ 24	4. 19. 44 p.m.	2. 27	—	—	12. 52	14. 12
17	„ 30	7. 56. 48 a.m.	0. 35	—	—	7. 30	10. 54
19	„ 31	11. 23. 29 p.m.	0. 24	—	—	1. 21	—
22	Feb. 3	1. 28. 44 p.m.	0. 48	—	—	9. 28	10. 40
24	„ 5	7. 20. 19 p.m.	1. 09	—	—	3. 52	18. 10
30	„ 13	3. 38. 17 p.m.	2. 17	—	—	5. 16	19. 10
35	„ 14	6. 31. 43 p.m.	1. 18	—	—	—	—
44	„ 26	7. 19. 30 a.m.	0. 34	—	—	1. 32	9. 00
52	March 4	3. 43. 46 p.m.	0. 14	—	—	—	—
56	„ 9	11. 29. 17 a.m.	2. 04	8. 00	7. 16	15. 16	15. 40
63	„ 14	5. 24. 41 p.m.	2. 00	—	—	—	—
73	„ 28	8. 3. 36 p.m.	0. 12	—	—	—	—
74	„ 29	2. 6. 15 p.m.	0. 46	—	—	—	20. 40
76	April 1	3. 51. 37 p.m.	0. 47	—	—	—	—
92	„ 27	4. 2. 59 p.m.	0. 11	—	—	—	5. 00
97	May 1	4. 47. 41 a.m.	0. 27	—	—	8. 44	—
98	„ 3	11. 36. 20 a.m.	0. 21	—	—	—	—
109	„ 18	1. 5. 37 p.m.	1. 14	—	—	5. 04	16. 05
110	„ 19	11. 48. 57 p.m.	0. 23	—	—	8. 00	6. 26
114	„ 24	5. 16. 53 p.m.	0. 30	—	—	7. 30	—
116	„ 27	10. 19. 35 a.m.	0. 14	—	—	—	2. 15
117	„ 30	1. 49. 57 p.m.	0. 10	—	—	—	—

EARTHQUAKES. (Group I.)

Average period in: 1st. P. T. Slow waves.	1st. P. T. Quick waves.	2nd P. T. Slow waves.	2nd P. T. Quick waves.	P. P. 1st phase.	P. P. 2nd phase.	P. P. 3rd phase.	E. P.	Maximum range of motion in: 1st. P. T.	2nd P. T.	P. P. 1st phase.	P. P. 2nd phase.	P. P. 3rd phase.
s	s	s	s	s	s	s	s	mm	mm	mm	mm	mm
—	—	—	—	—	27,5	14,2	—	—	—	—	—	—
7,2	—	13,0	7,1	34,8	—	13,4	10,9	0,04	0,11	0,4	0,2	0,44
15,9	—	—	—	40,0	—	14,0 (?)	—	0,26	—	1,5	—	1,2
12,0 (?)	—	—	—	—	14,2	10,7	—	—	—	—	0,04	0,05
—	—	11,8	—	—	19,0	13,2	—	Small	0,05	—	0,05	Small
14,1	5,3	15,3	7,3	32,7	21,0	15,5	15,7	0,06	0,08	0,13	0,13	0,25
10,2	4,9	—	—	—	17,2	13,4	9,7	0,05	—	—	0,19	—
21,0	—	—	—	—	—	16,7	—	Small	—	—	—	0,10
15,8	0,94	—	—	—	17,2	{13,6 5,4	—	„	—	—	0,04	—
16,6	—	—	—	—	24,2	17,8	14,2	„	—	—	Small	0,08
14,5	—	—	—	—	26,1	16,8	—	0,06	—	—	—	0,09
10,3	4,1	—	—	—	25,8	10,0	10,0	Small	—	—	0,13	2,10
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	13,1	9,3	9,1	Small	—	—	0,20	2,40
—	—	—	—	—	29,0	—	—	„	—	—	Small	—
7,6	4,1	13,4	7,4	—	23,2	12,3	12,3	0,04	1,30	—	0,09	2,10
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	14,7	—	—	—	—	0,06	—
—	—	—	—	21,8	13,9	9,3	—	—	—	—	0,10	0,10
—	—	—	—	—	—	8,7	—	—	—	—	0,04	—
—	—	—	—	—	—	9,5	—	—	—	—	—	0,05
4,8	—	—	—	—	—	7,2	—	0,03	—	—	—	0,05
—	—	—	—	—	—	11,1	—	—	—	—	—	0,08
—	—	—	—	27,2	17,2	12,2	—	—	—	—	—	0,05
3,9	0,88	—	—	—	—	6,2	4,8	0,01	—	—	—	0,13
7,8	4,0	—	—	—	—	10,6	—	—	—	—	—	Small
—	—	—	—	—	—	9,7	—	—	—	—	—	0,04
—	—	—	—	—	—	12,4	—	—	—	—	—	0,05

TABLE II.

No.	Date. 1900.	Time of occurrence. (1st N. J. T.)	Duration of Total eqke.	Duration of 1st. P. T.	Duration of 2nd P. T.	Duration of Total P. T.	Duration of P. P.
		h m s	h m	m s	m s	m s	m s
122	June 3	6. 38. 53 a.m.	2. 00	—	—	16. 50	42. 20
127	,, 10	4. 24. 44 p.m.	0. 16	—	—	—	—
129	,, ,,	7. 52. 02 p.m.	0. 48	—	—	15. 02	—
130	,, 13	5. 58. 36 a.m.	2. 10	—	—	—	24. 30
136	,, 22	6. 11. 09 a.m.	12. 00	14. 50	18. 40	33. 30	29. 30
137	,, 23	4. 38. 51 p.m.	1. 36	—	—	9. 30	14. 00
159	,, 26	2. 44. 38 p.m.	1. 30	—	—	6. 16	9. 45
169	,, 28	6. 04. 15 a.m.	0. 12	—	—	—	—
171	July 2	10. 47. 36 a.m.	0. 24	—	—	6. 13	—
189	,, 14	—	0. 08	—	—	0. 55	2. 49
201	,, 15	11. 09. 39 a.m.	0. 12	—	—	—	—
209	,, 21	3. 52. 07 p.m.	2. 05	7. 40	7. 03	14. 43	23. 50
213	,, 24	10. 01. 45 p.m.	0. 25	0. 41	0. 41	1. 22	6. 35
214	,, 25	2. 07. 06 a.m.	0. 36	0. 18	0. 19	0. 37	8. 50
218	,, 29	4. 08. 42 p.m.	4. 00	7. 39	4. 43	12. 22	29. 20
219	Aug. 1	8. 54. 41 a.m.	0. 19	—	—	2. 14	6. 20
220	,, ,,	3. 11. 35 p.m.	0. 56	—	—	10. 13	9. 30
221	,, ,,	5. 11. 12 p.m.	1. 30	—	—	15. 10	—
222	,, 2	1. 33. 21 p.m.	0. 27	—	—	3. 57	6. 40
224	,, ,,	3. 59. 25 p.m.	0. 11	—	—	—	—
225	,, ,,	6. 34. 23 p.m.	0. 24	—	—	—	10. 00
227	,, 3	2. 31. 13 p.m.	2. 45	—	—	13. 00	20. 40
236	,, 13	2. 36. 12 p.m.	0. 41	—	—	—	6. 00
237	,, 14	5. 19. 39 a.m.	3. 00	—	—	4. 50	12. 04
238	,, ,,	8. 00. 28 a.m.	0. 37	—	—	—	—

(*Continued.*)

Average period in								Maximum range of motion in				
1st. P. T.		2nd P. T.		P. P.			E. P.	1st P. T.	2nd P. T.	P. P.		
Slow waves.	Quick waves.	Slow waves.	Quick waves	1st phase.	2nd phase.	3rd phase.				1st phase.	2nd phase.	3rd phase.
s	s	s	s	s	s	s	s	mm	mm	mm	mm	mm
—	—	14,4	—	—	—	13,4	10,7	—	Small	—	—	0,01
—	—	—	—	—	—	—	—	—	—	—	—	—
—	5,4	—	—	28,3	—	12,7	—	Small	—	—	—	—
—	—	—	—	—	23,7 9,6	11,6	10,9	—	—	—	0,14	0,06
—	5,8	20,0	16,0 8,9	28,0	21,9	19,3	14,7	Small	0,10	0,06	0,08	0,38
—	5,9	—	—	—	18,5	18,5	10,6	—	—	—	Small	0,06
1,7 5,2	9,2	—	—	—	14,4	11,4	11,0	0,06	—	—	0,13	0,09
—	—	—	—	—	—	10,4	—	—	—	—	—	0,07
10,0	—	—	—	—	—	8,4	—	—	—	—	—	0,02
—	—	—	—	—	—	10,0	9,6	—	—	—	—	0,07
—	—	—	—	—	—	17,0	—	—	—	—	—	0,06
8,1	—	—	9,4	—	25,6	17,4	17,0	0,03	0,06	—	—	0,06
—	—	4,6	1,1	—	8,2 1,1	4,8 11,2	8,4	—	0,03	—	0,16	—
7,2	0,96	9,4	0,96	—	6,3 0,94	8,8	7,4	0,06	0,15	—	0,63	1,4
10,4 20,5	4,8 1,3	26,8	10,0	45,8 29,2	22,9	14,3	9,8 14,5	0,3	1,13	3,3	4,25	—
—	—	—	—	—	13,3	7,9	—	—	—	—	Small	0,05
—	—	—	—	—	16,5	13,4	11,1	—	—	—	,,	0,06
8,8	4,5	—	—	—	18,6	10,4	—	0,5	—	—	0,04	0,08
—	1,1	—	—	—	—	9,4	—	—	—	—	—	0,03
—	—	—	—	—	—	12,0	—	—	—	—	—	Small
—	—	—	—	—	—	8,4	—	—	—	—	—	0,06
—	4,7	8,3	—	—	14,0	10,8	9,9	—	—	—	0,06	0,04
—	—	—	—	—	—	9,4	—	—	—	—	—	0,03
8,3	3,8	—	—	25,6	15,8	8,8	9,4	0,06	—	0,14	0,23	0,49
—	—	—	—	—	14,9	—	—	—	—	—	—	—

TABLE II.

No.	Date. 1900.	Time of occurrence. (1st. N. J. T.)	Duration of Total eqke.	1st. P. T.	2nd. P. T.	Total. P. T.	P. P.
		h m s	h m	m s	m s	m s	m s
241	Aug. 21	3. 16. 12 a.m.	—	—	—	—	—
250	,, 29	3. 14. 09 p.m.	2. 0	—	—	3. 29	10. 10
255	Sept. 10	9. 29. 23 p.m.	0. 14	—	—	1. 21	3. 23
258	,, 15	8. 51. 27 p.m.	—	—	—	—	—
259	,, 18	7. 01. 41 a.m.	2. 30	—	—	9. 04	33. 00
260	,, ,,	9. 48. 41 a.m.	0. 14	—	—	—	—
262	,, 20	4. 11. 00 a.m.	1. 20	—	—	8. 40	8. 00
266	,, 29	11. 16. 32 p.m.	0. 20	—	—	4. 00	—
269	Oct. 2	9. 03. 04 p.m.	1. 00	—	—	11. 06	8. 54
272	,, 8	6. 06. 44 a.m.	Greater than 2. 00	5. 55	5. 00	10. 55	8. 55
273	,, ,,	6. 02. 16 p.m.	3. 00	8. 18	6. 45	15. 03	52. 00
274	,, ,,	10. 09. 35 p.m.	—	—	—	—	—
277	,, 9	9. 37. 14 p.m.	4. 00	7. 22	5. 05	12. 27	30. 20
278	,, 10	0. 35. 45 p.m.	1. 00	—	—	20. 40	15. 00
286	,, 17	8. 25. 40 p.m.	0. 47	—	—	6. 17	23. 20
288	,, 21	3. 35. 11 a.m.	1. 04	9. 56	11. 00	20. 56	11. 10
291	,, 29	6. 31. 52 p.m.	3. 15	16. 55	15. 33	32. 31	21. 54
333	Nov. 10	2. 20. 59 a.m.	1. 30	—	—	—	11. 00
341	,, 12	10. 14. 55 a.m.	1. 23	—	—	10. 10	16. 36
342	,, 13	3. 44. 34 a.m.	0. 20	—	—	1. 03(?)	—
345	,, ,,	6. 18. 03 a.m.	0. 15	—	—	—	5. 10
346	,, ,,	6. 32. 14 a.m.	0. 21	—	—	—	4. 30
348	,, 14	4. 43. 07 a.m.	0. 15	—	—	—	—
365	,, 24	4. 49. 13 p.m.	3. 40	—	—	3. 09	8. 38
371	Dec. 2	7. 59. 56 a.m.	0. 38	—	—	1. 18	9. 00

(*Continued.*)

Average period in								Maximum range of motion in				
1st. P. T.		2nd P. T.		P. P.			E. P.	1st P. T.	2nd P. T.	P. P.		
Slow waves.	Quick waves.	Slow waves.	Quick waves.	1st phase.	2nd phase.	3rd phase.				1st phase.	2nd phase.	3rd phase.
s	s	s	s	s	s	s	s	mm	mm	mm	mm	mm
—	—	—	—	—	—	10,0	—	—	—	—	—	0,08
4,2	1,0	—	—	—	17,8	13,1	10,0	—	—	—	0,13	0,11
—	0,93	—	—	—	—	{ 14,3 2,3 0,92	7,0	—	—	—	—	0,15
—	—	—	—	—	—	20,5(?)	—	—	—	—	—	—
15,2	{ 8,0 3,8	—	—	35.1	26,7	22,4	9,7	0,28	—	0,5	1,0	2,2
—	—	—	—	—	—	19,2	—	—	—	—	—	0,4
—	5,1	9,3	5,5	21,0	{ 17,9 9,0	18,0	9,3	—	0,15	0,28	0,1	0,11
—	5,4	—	—	—	—	7,0	9,1	0,3	—	—	—	0,44
—	4,7	—	—	—	24,6	{ 7,9 20,0	—	—	—	—	0,5	—
9,6	{ 4,9 2,7	25,	9,9	24(?)	17,1	15,9	16,1	0,12	0,4	—	2,85	1,6
5,1	{ 3,5 1,1	21,2	8,6	—	25,2	18,6	17,1	0,05	0,15	—	0,13	0,19
—	—	—	—	—	25,5	—	—	—	—	—	—	—
14,2	{ 4,8 1,5	{ 19,6 24,8	7,8	{ 7,5 44,7	35,7	21,4	{ 22,0 9,2	0,56	1,8	1,5	4,3	1,5
10,2	—	—	—	—	—	16,6	11,2	—	—	—	—	0,06
9,0	—	—	—	—	22,3	18,4	—	0,06	—	—	0,06	0,06
—	—	14,6	8,1	—	22,5	{ 8,6 16,8	{ 9,3 17,2	—	0,11	—	0,07	0,06
14,0	7,4	32,6	{ 7,8 15,6	{ 2,9 10,0 56,0	{ 10,3 45,4	25,8	17,5	0,11	0,38	0,25	0,43	0,44
—	0,88	—	—	—	—	8,3	—	0,05	—	—	—	0,24
9,6	—	—	—	41,5	23,	17,0	{ 10,8 17,4	0,23	—	0,45	0,36	1,11
—	—	—	—	23,1	—	{ 15,0 1,1	11,8	—	—	0,04	—	—
—	—	—	—	—	{ 0,84 4,6 12,6	5,9	6,9	—	—	—	0,65	0,43
—	—	—	—	{ 3,1 24,6	12,1	8,0	9,1	—	—	0,35	0,46	0,52
—	—	—	—	—	—	—	—	—	—	—	—	—
{ 8,1 38,0	{ 0,84 3,7	—	—	{ 3,8 7,6 34,6	—	{ 6,2 13,5	{ 9,4 17,8	0,36	—	1,5	—	1,7
7,7	0,98	—	—	—	14,2	9,1	7,8	0,11	—	—	0,4	—

TABLE II.

No.	Date. 1900.	Time of occurrence. (1st. N. J. T.)	Duration of Total eqke.	1st P. T.	2nd P. T.	Total. P. T.	P. P.
		h m s	h m	m s	m s	m s	m s
372	Dec. 3	11. 07. 02 p.m.	2. 00	—	—	0. 40	13. 04
373	„ 4	0. 16. 23 a.m.	0. 13	—	—	2. 15	—
376	„ 7	4. 13. 05 p.m.	2. 00	—	—	2. 13	12. 13
379	„ 17	5. 07. 57 p.m.	0. 30	—	—	9. 30	9. 23
380	„ 19	7. 31. 40 a.m.	1. 35	—	—	8. 38	9. 41
383	„ 25	2. 7. 44 p.m.	3. 30	—	—	2. 30.	0. 26

TABLE III. EARTHQUAKES WHICH COAST OF HOKKAIDO.

No.	Date. 1900.	Time of occurrence. (1st. N.J. T.)	Duration of Total eqke.	1st P. T.	2nd P. T.	Total P. T.	P. P.	Average 1st P. T. Slow waves.	1st P. T. Quick waves.	2nd P. T. Quick waves.	2nd P. T. Quick waves.
		h m s	h m	m s	m s	m s	m s	s	s	s	s
12	Jan. 18	4. 44. 44 p.m.	1. 00	—	—	2. 00	6. 00	4,0	—	—	—
20	Feb. 1	4. 21. 07 a.m.	1. 30	1. 00	1. 18	2. 18	8. 35	7,2	0,92	{ 7,2 19,2	{ 1,1 2,6
23	„ 13	1. 27. 40 p.m.	1. 26	1. 03	0. 49	1. 52	6. 30	12,7	1,23	9,8	0,96
43	„ 24	9. 20. 07 p.m.	0. 43	0. 51	0. 51	1. 42	7. 07	—	1,15	3,2	1,17
61	March 12	7. 55. 53 p.m.	0. 12	—	—	1. 20	1. 56	—	1,22	—	—
124	June 8	5. 23. 58 p.m.	0. 10	—	—	1. 10	—	—	1,18	—	—
249	Aug. 2	11. 31. 20 a.m.	2. 48	—	—	1. 35	1. 25	11,5	{ 0,95 3,6	—	—
293	Nov. 2	3. 3. 59 p.m.	0. 15	—	—	1. 18	—	—	1,05	—	—

(*Continued.*)

Average period in								Maximum range of motion in				
1st P. T.		2nd P. T.		P. P.			E. P.	1st P. T.	2nd P. T.	P. P.		
Slow waves.	Quick waves.	Slow waves.	Quick waves.	1st. phase.	2nd phase.	3rd phase.				1st phase.	2nd phase.	3rd phase.
s	s	s	s	s	s	s	s	mm	mm	mm	mm	mm
9,9	—	—	—	—	{ 8,2 / 21,7	13,5	8,2	—	—	—	0,31	1,08
—	—	—	—	—	—	8,5	—	—	—	—	—	0,05
—	1,0	—	—	26,2	19,1	—	10,4	—	—	0,1	0,25	—
9,5	—	—	—	—	21,8	13,8	10,6	—	—	—	—	0,06
5,1	—	10,0	6,9	—	19,5	16,6	—	0,03	0,05	—	—	0,06
27,4	{ 1,1 / 3,7	—	—	—	{ 3,6 / 32,8	{ 9,0 / 14,1	10,2	2,7	—	—	10,9	6,0

ORIGINATED OFF THE SOUTH-EASTERN

(Group II.)

period in				Maximum range of motion in									
P. P.			E. P.	1st P. T.		2nd P. T.		P. P.					
1st phase.	2nd phase.	3rd phase.						1st phase.		2nd phase.		3rd phase.	
				(Slow vibr.)	(Quick vibr.)	(Slow vibr.)	(Quick vibr.)	(Slow vibr.)	(Quick vibr.)	(Slow vibr.)	(Quick vibr.)	(Slow vibr.)	(Quick vibr.)
s	s	s	s	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
{ 2,4 / 28,0	—	{ 5,0 / 12,7	8,9	—	—	—	—	0,19	—	—	—	0,18	—
—	17,8	{ 1,4 / 2,3 / 6,9	8,0	0,05	0,03	0,05	0,03	—	—	—	—	1,7	0,38
19,5	{ 2,5 / 12,7	8,2	8,6	—	0,05	0,34	0,19	0,50	—	—	—	0,3	—
16,8	12,0	{ 1,16 / 3,7 / 7,9	{ 4,6 / 9,8	—	—	—	0,14	0,31	—	—	—	0,28	—
—	—	1,02	{ 2,2 / 8,3	—	—	—	—	—	—	—	—	—	0,11
—	—	{ 1,00 / 3,3 / 7,3	—	—	—	—	—	—	—	—	—	0,06	—
{ 0,95 / 4,9 / 31,8	—	{ 5,7 / 12,3	10,0	0,81	0,31	—	—	2,6	1,1	—	—	{ 4,6 / 4,0	—
{ 1,00 / —	—	6,5	—	—	—	—	—	—	—	—	—	0,04	—

TABLE IV. EARTHQUAKES WHICH COAST OF HONSHŪ.

No.	Date. 1900.		Time of occurrence. (1st N. J. T.)	Duration of Total eqke.	Duration of 1st P. T.	Duration of 2nd P. T.	Duration of Total P. T.	Duration of P. P.
			h m s	m s	m s	m s	m s	m s
8	Jan.	17	5. 31. 45 a.m.	13. 00	—	—	0. 50	5. 00
45	Feb.	26	11. 34. 16 a.m.	8. 20	—	—	0. 13	1. 14
59	March	12	10. 35. 01 a.m.	79. 20	0. 23	0. 23	0. 46	16. 00
62	,,	13	1. 09. 38 a.m.	10. 10	—	—	0. 11(?)	4. 05
67	,,	17	1. 37. 45 p.m.	18. 40	0. 35	0. 35	1. 10	2. 42
78	April	16	7. 13. 35 p.m.	8. 04	—	—	0. 52	—
101	May	12	3. 23. 18 a.m.	120. 00	—	—	0. 40	15. 00
103	,,	,,	11. 44. 36 a.m.	8. 20	—	—	0. 34(?)	1. 55
105	,,	14	4. 49. 44 a.m.	4. 05	—	—	0. 42	0. 49
118	,,	31	1. 20. 7 a.m.	17. 40	0. 34	0. 26	1. 00	5. 20
121	June	2	9. 07. 29 a.m.	24. 50	0. 45	0. 38	1. 23	5. 40
170	,,	30	2. 51. 25 p.m.	5. 40	—	—	0. 40	0. 55
230	Aug.	5	1. 21. 17 p.m.	225. 00	—	—	0. 39	17. 00
252	Sept.	5	6. 02. 29 p.m.	4. 20	—	—	0. 23	1. 13
253	,,	6	2. 20. 15 a.m.	2. 40	—	—	0. 17	1. 08
263	,,	24	0. 35. 22 p.m.	13. 50	0. 19(?)	0. 36	0. 55(?)	5. 30
271	Oct.	3	3. 50. 56 a.m.	7. 35	0. 37	0. 35	1. 12	1. 02
284	,,	16	0. 27. 27 p.m.	5. 35	—	—	0. 30	1. 27
332	Nov.	9	11. 41. 36 p.m.	1. 33	—	—	—	—
347	,,	13	7. 36. 11 a.m.	74. 00	—	—	0. 54	12. 07
355	,,	15	6. 37. 30 a.m.	34. 10	—	—	0. 46	6. 21
369	Dec.	2	1. 33. 41 a.m.	2. 47	—	—	0. 10	—
375	,,	6	2. 01. 21 p.m.	10. 42	—	—	0. 34	3. 32

ORIGINATED OFF THE NOTH-EASTERN

(**Group III.**)

Average period in							Max. range of motion in					
1st P. T.		2nd P. T.		P. P.		E. P.	1st P. T.		2nd P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.	1st phase.	2nd phase.		Slow waves.	Quick waves.	Slow waves.	Quick waves.	1st phase.	2nd phase.
s	s	s	s	s	s	s	mm	mm	mm	mm	mm	mm
—	—	—	—	7,2	—	—	—	—	—	—	—	—
—	1,0	—	—	21,2	0,87	{0,99 2,6 4,3	—	—	—	—	—	0,45
{8,3 1,8(?)	0,83	8,3	0,93	7,0	0,91	9,7	—	0,08	—	0,31	3,1	1,8
2,4	—	—	—	4,1 (also 2,7 and 15,4)	0,89	—	—	—	—	—	0,06	0,04
—	1,16	—	1,03	{6,7 4,4	1,03	6,1	—	—	—	—	0,09	0,04
—	0,94	—	—	{3,5 7,6	1,03	—	—	—	—	—	0,05	—
—	—	12,8	—	{20,0 4,2	1,9	8,4	—	0,19	2,4	—	{10,9 9,1	7,0
—	1,12	—	—	2,9	0,93	4,2	—	—	—	—	0,03	—
—	0,81	—	—	—	0,78	0,88	—	—	—	—	—	0,04
—	—	—	0,61	{3,2 8,0	0,84	—	—	—	—	—	0,04	0,04
—	—	—	1,14	5,9	1,0	{9,9 4,1	—	—	—	—	0,11	—
—	1,08	—	—	—	0,89	1,07	—	—	—	—	—	0,03
3,0	0,67	24,0	1,6	{6,2 15,2	{3,8 2,1	8,8	—	—	2,1	0,9	{5,4 5,9	{3,9 2,9
—	—	—	0,94	—	0,94	0,99	—	—	—	—	—	—
—	—	—	—	—	0,96	—	—	—	—	—	—	—
—	0,78	3,8	0,87	{6,7 3,6	0,91	5,0	—	—	0,04	0,03	{0,11 0,21	0,30
—	—	—	0,94	—	0,94	—	—	—	—	—	—	—
—	0,87	—	—	—	0,86	0,92	—	—	—	—	—	0,08
—	—	—	—	—	—	—	—	—	—	—	—	—
—	0,92	—	—	{21,0 16,1	—	10,9	—	—	—	—	{0,08 0,15	—
—	—	10,3	—	{9,3 25,7(?)	0,94	7,2	—	—	0,13	—	{1,1 10,4	—
—	—	—	—	10,4	—	—	—	—	—	—	—	—
—	0,95	—	—	4,1	0,97	—	—	—	—	—	0,06	0,09

TABLE V. EARTHQUAKES WHICH OF THE KAZUSA-AWA

No.	Date. 1900.		Time of occurrence. (1st N. J. T.)	Duration of Total eqke.	Duration of 1st P. T.	Duration of 2nd P. T.	Duration of Total P. T.	Duration of P. P.
			h m s	m s	m s	m s	m s	m s
18	Jan.	31	2. 37. 51 a.m.	6. 00	0. 15	0. 18	0. 33	1. 50
37	Feb.	16	10. 50. 27 a.m.	6. 20	0. 11	0. 11	0. 22	1. 26
53	March	4	4. 45. 32 p.m.	6. 20	—	—	0. 19	0. 26
54	"	7	7. 15. 53 p.m.	3. 06	—	—	0. 20	0. 57
60	"	12	1. 41. 15 p.m.	10. 00	—	—	0. 17 (?)	1. 31
64	"	14	11. 56. 04 p.m.	7. 35	—	—	0. 15	1. 46
79	April	18	2. 14. 30 p.m.	2. 24	—	—	0. 17	—
112	May	21	10. 47. 53 p.m.	6. 35	—	—	0. 22(?)	1. 20
138	June	24	3. 59. 40 p.m.	5. 24	—	—	0. 18	1. 07
152	"	25	9. 12. 08 a.m.	Short	—	—	—	—
153	"	"	10. 31. 11 a.m.	3. 06	—	—	0. 08	0. 55
154	"	"	10. 28. 42 p.m.	Short	—	—	—	—
155	"	26	5. 09. 45 a.m.	"	—	—	—	—
160	"	"	6. 57. 53 p.m.	21. 20	0. 06	0. 06	0. 12	2. 22
161	"	"	9. 17. 46 p.m.	2. 10	—	—	—	—
229	Aug.	4	1. 33. 40 p.m.	70. 00	—	—	1. 51	7. 48
240	"	17	5. 26. 58 p.m.	5. 16	0. 17	0. 13	0. 30	1. 10
270	Oct.	3	3. 21. 09 a.m.	9. 42	—	—	0. 29	1. 41
279	"	10	2. 00. 56 p.m.	5. 33	—	—	0. 16 (?)	1. 59

ORIGINATED OFF THE EASTERN COAST PENINSULA. (Group IV.)

Average period in							Maximum range of motion in					
1st P. T.		2nd P. T.		P. P.		E. P.	1st P. T.		2nd P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.	1st phase.	2nd phase.		Slow waves.	Quick waves.	Slow waves.	Quick waves.	1st phase.	2nd phase.
s	s	s	s	s	s	s	mm	mm	mm	mm	mm	mm
—	0,93	3,0	0,90	—	0,85	0,95 3,6	—	0,01	—	0,01	—	0,31
—	1,01	—	0,96	3,3 20,7	0,86	1,08 3,6	—	—	—	0,04	—	0,44
—	1,12	—	—	—	0,85	0,86 3,8	—	—	—	—	—	0,35
—	1,05	—	—	—	0,88	—	—	—	—	—	—	0,04
—	—	3,0	1,3	3,1	1,22	2,1 4,2	—	—	—	—	—	0,33
—	0,80	—	—	2,9 11,6	—	—	—	—	—	—	—	0,15
—	—	—	—	—	0,85	—	—	—	—	—	—	—
—	0,91	—	—	—	1,04	1,26	—	—	—	—	—	0,03
—	—	—	—	—	0,95	1,02	—	—	—	—	—	0,06
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	0,64	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	0,84	2,0	0,84	2,5 5,2	0,98	3,2 6,7 4,6	—	—	—	0,1	0,56	0,66
—	—	—	—	—	—	—	—	—	—	—	—	—
2,1	0,90	2,4	—	5,2	0,85	8,9	—	0,31	—	—	0,31	0,7
—	0,94	—	1,10	—	0,94	0,98	—	—	—	—	—	0,05
—	—	—	—	—	0,99	1,03 2,8	—	0,08	—	—	—	2,1
—	—	—	0,81	9,5	1,45 0,72	4,2	—	—	—	—	—	0,04

TABLE VI. EARTHQUAKES WHICH IZU ISLANDS.

No.	Date. 1900.		Time of occurrence (1st N. J. T.)	Duration of Total eqke.	Duration of 1st P. T.	Duration of 2nd P. T.	Duration of Total P. T.	Duration of P. P.
			h m s	m s	m s	m s	m s	m s
11	Jan.	18	4. 26. 28 p.m.	2. 35	—	—	0. 13	—
208	July	21	7. 29. 5 a.m.	12. 10	—	—	1. 12	1. 21
292	Nov.	1	9. 50. 15 a.m.	24. 00	—	—	0. 13 (?)	0. 50
294	„	5	9. 16. a.m.	13. 00	—	—	—	—
295	„	„	—— a.m.	—	—	—	—	—
296	„	„	2. 10. 41 p.m.	34. 10	—	—	0. 25	2. 10
297	„	„	2. 47. 57 p.m.	5. 38	—	—	0. 20	—
298	„	„	2. 53. 44 p.m.	1. 34	—	—	—	—
299	„	„	3. 7. 29 p.m.	3. 53	—	—	—	—
300	„	„	4. 14. 58 p.m.	1. 35	—	—	—	—
301	„	„	4. 41. 42 p.m.	(more than 4h)	0. 17(?)	0. 10(?)	0. 27	13. 22
302	„	„	5. 05. 32 p.m.	10. 50	—	—	0. 25	1. 23
303	„	„	5. 19. 34 p.m.	30. 00	—	—	0. 24	10. 38
304	„	„	6. 39. 22 p.m.	1. 34	—	—	—	—
305	„	„	7. 11. 40 p.m.	3. 39	—	—	—	—
306	„	„	7. 15. 02 p.m.	2. 08	—	—	—	—
307	„	„	7. 17. 26 p.m.	4. 20	—	—	—	—
308	„	„	7. 26. 49 p.m.	1. 35	—	—	—	—
309	„	„	7. 38. 36 p.m.	15. 50	—	—	0. 19	2. 35
310	„	„	7. 55. 18 p.m.	2. 02	—	—	—	—
311	„	„	8. 12. 48 p.m.	1. 54	—	—	—	—
312	„	„	8. 24. 44 p.m.	2. 46	—	—	—	—
313	„	„	8. 52. 57 p.m.	3. 36	—	—	—	—
314	„	„	8. 58. 49 p.m.	0. 39	—	—	—	—
315	„	„	9. 17. 56 p.m.	13. 50	—	—	0. 19	2. 30
316	„	„	9. 35. 46 p.m.	10. 5	—	—	0. 20	3. 15
317	„	„	9. 45. 27 p.m.	20. 00	—	—	0. 21	4. 54
318	„	6	0. 42. 19 a.m.	8. 35	0. 11	0. 09	0. 20	1. 54
319	„	„	3. 48. 41 a.m.	1. 35	—	—	0. 14	—

ORIGINATED UNDER THE SEAS OF THE (Group V.)

Average period in							Max. range of motion in					
1st P. T.		2nd P. T.		P. P.		E. P.	1st P. T.		2nd P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.	1st phase.	2nd phase.		Slow waves.	Quick waves.	Slow waves.	Quick waves.	1st phase.	2nd phase.
s	s	s	s	s	s	s	mm	mm	mm	mm	mm	mm
—	—	—	—	—	—	—	—	—	—	—	—	0,13
—	—	—	0,92	1,4 1,9	0,80	1,01 4,2 8,5	—	—	—	—	—	0,06
—	—	—	—	—	0,86	0,86	—	—	—	—	—	0,13
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	1,13	—	—	11,4	1,06	—	—	—	—	—	—	0,4
—	—	—	—	—	1,18	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	1,2	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
17,1	1,11	—	1,45	7,1	—	6,9 (Towards very end 8,2)	1,8	0,46	—	5,8	Greater than 30	—
—	1,14	—	—	—	1,03	—	—	—	—	—	—	0,25
—	0,87	—	—	22,0 13,9 8,3	1,14	7,5	—	—	—	—	1,4 2,4 2,7	0,38
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	1,06	—	—	—	—	—	—	—
—	—	—	—	—	1,02	—	—	—	—	—	—	—
—	—	—	—	—	1,02	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	0,89	—	—	12,2 8,3	0,83	7,2	—	—	—	—	0,15 0,16	0,25
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	0,95	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	1,08	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	1,02	—	—	7,8	0,85	8,5	—	—	—	—	0,18	[illegible]
—	—	—	—	14,4 7,3	0,67	7,3	—	—	—	—	0,11 0,25	—
—	0,92	—	—	13,8 9,9	1,01	8,6 4,0	—	—	—	—	0,20 0,18	—
—	—	—	—	2,4	0,89	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE VI.

No.	Date. 1900.		Time of occurrence. (1st N. J. T.)	Duration of Total eq. e.	Duration of 1st P. T.	Duration of 2nd P. T.	Duration of Total P. T.	Duration of P. P.
			h m s	m s	m s	m s	m s	m s
320	Nov.	6	1. 49. 59 p.m.	5. 35	—	—	0. 27	2. 49
321	"	"	3. 50. 14 p.m.	4. 50	—	—	0. 15 (?)	—
322	"	"	3. 58. 38 p.m.	0. 54	—	—	—	—
323	"	"	6. 13. 54 p.m.	53. 00	—	—	0. 24	12. 8
324	"	8	2. 57. 47 a.m.	5. 19	—	—	0. 14	—
325	"	"	6. 49. 02 p.m.	5. 00	—	—	—	—
326	"	9	1. 41. 19 a.m.	10. 51	—	—	1. 8	3. 35
327	"	"	1. 52. 19 a.m.	6. 4	—	—	0. 47	—
328	"	"	2. 55. 03 a.m.	(more than 2 hs)	0. 56	0. 43	1. 39	14. 35
329	"	"	5. 45. 20 a.m.	10. 30	—	—	0. 16	1. 31
330	"	"	11. 29. 59 a.m.	20. 20	—	—	1. 05	3. 10
334	"	10	5. 27. 07 a.m.	12. 00	—	—	—	—
335	"	"	7. 12. 31 a.m.	11. 30	—	—	0. 39	2. 31
337	"	"	8. 1. 35 p.m.	2. 42	—	—	—	—
339	"	11	3. 46. 29 p.m.	2. 44	—	—	0. 14	1. 26
340	"	"	3. 23. 00 a.m.	2. 42	—	0. 8 (?)	—	1. 08
363	"	19	10. 58. 39 p.m.	19. 40	0. 12	0. 13	0. 25	2. 47
368	Dec.	1	0. 33. 14 p.m.	16. 30	—	—	0. 25	2. 04

(*Continued.*)

Average period in							Max. range of motion in					
1st P. T.		2nd P. T.		P. P.		E. P.	1st P. T.		2nd P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	s	s	mm	mm	mm	mm	mm	mm
—	—	—	—	4,5	1,02	—	—	—	—	—	0,05	0,02
—	—	—	—	—	1,11	—	—	—	—	—	—	0,19
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	1,02	17,2 11,4	1,7 1,2	6,4 11,0	—	—	—	0,18	2,4 1,8	0,7 —
—	—	—	—	6,8	1,0	6,8	—	—	—	—	0,02	—
—	—	—	—	7,5	0,99	—	—	—	—	—	0,04	—
—	1,07	—	—	8,0	—	—	—	—	—	—	0,05	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	0,81	3,1 9,3	—	27,6 12,9 9,9 7,8	—	7,8 9,3	—	0,04	— —	0,33	15,5 22,0 21,1 21,9	—
—	0,76	—	—	—	0,85	3,1	—	—	—	—	0,13	—
—	0,98	—	—	11,8 8,3	1,06	9,1 3,9	—	—	—	—	0,24 0,19	0,18
—	—	—	—	7,1	—	—	—	—	—	—	0,05	—
—	0,89	—	—	7,8	—	—	—	—	—	—	0,11	—
—	—	—	—	—	1,00	—	—	—	—	—	—	—
—	—	—	—	—	1,01	—	—	—	—	—	—	—
—	—	—	—	—	0,89	—	—	—	—	—	—	0,04
—	—	—	0,91	10,4	0,97	9,3 3,4	—	—	—	0,08	0,5	0,44
—	—	—	0,95	4,2 11,8	0,94	—	—	—	—	—	0,13 0,18	0,14

TABLE VII. EARTHQUAKES WHICH JAPAN.

No.	Date. 1900.	Time of occurrence. (1st N. J. T.)	Duration of Total eqke.	1st P. T.	2nd P. T.	Total P. T.	P. P.
		h m s	h m	m s	m s	m s	m s
121	Feb. 2	5. 04. 26 p.m.	0. 55	—	—	2. 44	6. 22
126	June 9	9. 12. 45 p.m.	1. 17	2. 15	2. 00	4. 15	7. 10
257	Sept. 15	1. 23. 27 p.m.	0. 24	—	—	1. 19	5. 17

TABLE VIII. EARTHQUAKES WHICH JAPAN.

		h m s	m s	m s	m s	m s	m s
7	Jan. 17	0. 13. 36 a.m.	14. 00	—	—	0. 15	2. 15
69	March 22	0. 56. 07 a.m.	17. 50	—	—	0. 43	1. 47
120	May 31	5. 45. 17 p.m.	8. 25	—	—	0. 36	1. 48
268	Oct. 2	3. 37. 51 a.m.	18. 40	—	—	0. 11	0. 54
366	Nov. 27	9. 16. 01 p.m.	4. 13	—	—	0. 51	—

TABLE XI. EARTHQUAKES OF

		h m s	m s	m s	m s	m s	m s
4	Jan. 13	1. 20. 26 a.m.	11. 00	—	—	1. 29	3. 00
75	March 29	4. 38. 52 p.m.	4. 21	—	—	0. 28	—
85	April 25	8. 18. 52 a.m.	(the two eqkes lasted together 2h 22m)	0. 19	0. 19	0. 38	1. 20
85	,, ,,	8. 23. 02 a.m.		—	—	0. 48	16. 52
113	May 21	0. 11. 17 a.m.	19. 20	—	—	1. 33	5. 50

ORIGINATED IN WESTERN (Group VI.)

Average period in							Maximum range of motion in					
1st P. T.		2nd P. T.		P. P.		E. P.	1st P. T.		2nd P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	s	s	mm	mm	mm	mm	mm	mm
—	—	—	—	25,4	22,2	7,7	—	—	—	—	0,09	—
8,4	1,1	9,7	—	—	17,2 5,2	8,5	0,04	—	0.06	—	0,44	—
—	0,98	—	—	—	10,4 2,4 1,4	7,3	—	—	—	—	0,13	0,17

ORIGINATED IN CENTRAL (Group VII.)

s	s	s	s	s	s	s	mm	mm	mm	mm	mm	mm
—	—	—	—	7,9	0,87	—	—	0,13	—	—	1,0	0,68
—	—	4,8	1,24	2,8 7,7 30,6	1,05	3,7 7,4	—	—	0,08	0,06	0,43	0,4
—	0,99	—	—	3,4	0,93	—	—	—	—	—	0,08	0,06
—	—	—	—	—	0,97	0,99	—	—	—	—	—	0,03
—	0,94	—	—	7,5	1,07	—	—	—	—	—	0,08	0,03

MISCELLANEOUS ORIGINS. (Group IX.)

s	s	s	s	s	s	s	mm	mm	mm	mm	mm	mm
—	—	—	—	7,5 15,0	—	—	0,13	—	—	—	0,5	—
—	—	—	1,1	9,6	1,08	—	—	—	—	—	—	—
—	0,78	2,2	0,76	4,1	0,82	4,5 8,2	—	—	—	0,06	0,23	0,48
2,9 18,1	0,93	—	—	7,4 17,3	1,68	8,8	0,45	0,44	—	—	1,14	0,25
—	1,03	—	—	3,8 7,6	1,06	4,5	—	—	—	—	0,13	0,16

TABLE IX. LOCAL EARTHQUAKES (**Group VIII, A**)

No.	Date. 1900.	Time of occurrence. (1st N. J. T.)	Duration of: Total eqke.	Duration of: P. T.	Duration of: P. P.
		h m s	m s	m s	m s
6*	Jan. 15	0. 33. 07 p.m.	5. 30	—	—
14	,, 21	6. 27. 14 p.m.	3. 56	0. 6	0. 44
23*	Feb. 3	7. 9. 55 p.m.	4. 50	0. 17	1. 34
25	,, 9	6. 38. 48 a.m.	3. 23	0. 07	1. 21
38†	,, 16	4. 35. 00 p.m.	2. 24	0. 14	—
39	,, 17	0. 52. 32 p.m.	3. 40	0. 07	1. 04
40	,, 18	2. 46. 54 a.m.	2. 38	0. 04(?)	—
41	,, 18	8. 03. 43 p.m.	3. 02	0. 08	1. 14
42†	,, 20	11. 50. 42 p.m.	2. 55	0. 06	0. 30
46	March 1	7. 32. 14 a.m.	2. 28	0. 2(?)	—
47	,, ,,	10. 08. 11 p.m.	3. 10	1.P.T.:— 0. 07 2.P.T.:— 0. 07	2. 05
50	,, 4	11. 58. 09 a.m.	12. 00	1.P.T.:— 0. 06 2.P.T.:— 0. 03	1. 48
57	,, 9	6. 01. 11 p.m.	5. 50	0. 10	0. 59
65	,, 15	6. 23. 40 p.m.	4. 13	0. 10	0. 41
66	,, 16	10. 02. 22 p.m.	8. 30	0. 11	0. 49
70	,, 26	5. 32. 34 p.m.	17. 40	0. 12	0. 22
71	,, ,,	8. 54. 33 p.m.	9. 40	0. 09	1. 41
77	April 15	7. 51. 27 a.m.	14. 20	0. 11	2. 03
80	,, 20	9. 08. 05 p.m.	3. 14	0. 11	0. 56
87*	,, 25	0. 19. 28 p.m.	2. 3[illegible]	0. 29	0. 35
99	May 5	9. 16. 10 a.m.	3. 42	0. 15	1. 12
106	,, 15	7. 12. 50 a.m.	13. 00	0. 13	1. 56
107	,, ,,	9. 04. 00 p.m.	4. 10	0. 06	0. 34
111*	,, 21	8. 27. 26 a.m.	5. 30	0. 09	0. 51
119	,, 31	5. 39. 58 a.m.	10. 10	1.P.T.:— 0. 11 2.P.T.:— 0. 11	3. 18
125	June 8	8. 30. 56 p.m.	4. 00	0. 06	1. 48
128	,, 10	7. 29. 19 p.m.	3. 20	0. 14	0. 45
131*	,, 13	1. 42. 51 p.m.	0. 15	0. 03	—

RECORDED AT ONE OR MORE STATIONS.

{ † Recorded only in Tokyo.
{ * Not recorded in Tokyo.

Average period in					Maximum range of motion in			
P. T.		P. P.		E. P.	P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	mm	mm	mm	mm
—	—	10,6	—	—	—	—	0,20	—
—	—	—	0,90	0,98	—	0,03	—	0,8
—	0,85	—	0,84	1,11	—	—	—	0,09
—	1,05	—	0,73	1,92	—	—	—	0,01
—	1,20	3,3	1,09	—	—	—	—	—
6,5	—	—	0,77	{ 1,00 4,7	—	—	—	0,35
—	—	—	0,91	—	—	—	—	—
—	0,70	—	0,98	—	—	—	—	0,09
—	0,92	—	0,64	—	—	—	—	0,04
—	—	—	0,83	—	—	—	—	—
—	—	2,4(?)	1,02	—	—	—	—	0,05
—	0,98	3,8	0,84	3,4	—	0,19	—	0,7
—	1,13	—	0,94	1,08	—	—	—	0,15
—	1,00	—	1,00	1,01	—	—	—	0,1
—	1,04	—	1,04	{ 1,05 4,0	—	0,04	—	0,3
3,0	0,86	{ 5,0 7,3	0,99	{ 4,7 7,1	—	0,03	—	0,4
2,3	0,85	—	0,80	1,09	—	0,10	—	0,65
2,5	0,88	4,0	1,03	4,4	0.5	0,33	—	1,03
—	0,76	—	0,68	—	—	—	—	0,15
—	0,86	—	0,83	—	—	—	—	0,04
—	—	—	0,82	—	—	—	—	0,06
—	—	2,5	0,94	2,9	—	0,11	—	0,90
—	—	—	—	—	—	—	—	0,25
—	0,68	—	0,69	0,92	—	—	—	0,35
—	0,83	{ 2,6 10,3	0,75	3,8	—	—	0,13	0,13
—	—	—	0,96	—	—	—	—	0,06
—	—	—	0,88	1,01	—	—	—	0,03
—	—	—	—	—	—	—	—	—

TABLE IX.

No.	Date. 1900.		Time of occurrence. (1st N. J. T.)			Duration of Total eqke.	Duration of P. T.	Duration of P. P.
			h	m	s	m s	m s	m s
135*	June	20	4.	31.	30 p.m.	2. 30	—	—
163	,,	26	9.	48.	35 p.m.	4. 45	1. P. T.:— 0. 06 2. P. T.:— 0. 06	—
164†	,,	,,	10.	15.	09 p.m.	2. 39	0. 08	—
165	,,	,,	10.	19.	43 p.m.	3. 12	1. P. T.:— 0. 08 2. P. T.:— 0. 08	1. 46
166	,,	27	0.	53.	39 a.m.	1. 49	0. 06	0. 34
172	July	2	5.	38.	27 p.m.	12. 55	0. 11	1. 44
177	,,	8	11.	47.	38 a.m.	19. 10	1. P. T.:— 0. 07 2. P. T.:— 0. 07	4. 15
180	,,	10	11.	45.	25 p.m.	9. 10	1. P. T.:— 0. 04 2. P. T.:— 0. 04	1. 51
184	,,	13	7.	19.	53 p.m.	3. 44	0. 07	1. 02
187	,,	,,	10.	21.	26 p.m.	2. 21	—	0. 14
188	,,	14	7.	19.	05 a.m.	2. 19	0. 06	0. 15
190	,,	,,	8.	11.	37 a.m.	4. 00	0. 07	0. 74
191	,,	,,	8.	24.	17 a.m.	4. 33	1. P. T.:— 0. 06 2. P. T.:— 0. 05	0. 56
204	,,	16	5.	32.	37 p.m.	6. 47	0. 16	1. 39
207†	,,	20	4.	34.	35 p.m.	4. 15	1. P. T.:— ? 2. P. T.:— 0. 04	1. 10
212*	,,	24	9.	52.	27 p.m.	3. 49	0. 05	1. 26
223*	Aug.	2	3.	42.	41 p.m.	1. 00	—	—
226*	,,	,,	7.	17.	20 p.m.	Short	—	—
231	,,	8	7.	15.	04 p.m.	3. 04	0. 10	0. 52
232*	,,	13	1.	19.	07 a.m.	5. 14	0. 07	1. 12
233*	,,	,,	1.	45.	01 a.m.	1. 30	—	—
239	,,	17	6.	56.	24 a.m.	2. 34	0. 06	0. 26
244*	,,	27	2.	15.	49 a.m.	2. 55	0. 08	0. 32
245	,,	,,	2.	59.	52 p.m.	8. 53	0. 04	1. 32
246	,,	,,	4.	27.	35 p.m.	4. 25	1. P. T.:— 0. 12 2. P. T.:— 0. 07	0. 45

(*Continued*).

Average period in					Maximum range of motion in			
P. T.		P. P.		E. P.	P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves	Quick waves.
s	s	s	s	s	mm	mm	mm	mm
—	—	—	—	—	—	—	—	0,08
—	0,89	—	1,4	{ 0,91 3,4	—	—	—	0,4
—	0,89	—	0,94	—	—	—	—	—
—	0,84	—	0,88	2,9	—	—	—	0,05
—	—	—	0,84	0,97	—	—	—	0,03
—	0,87	7,3	0,86	3,4	—	—	0,13	0,16
—	0,95	3,5	0,89	3,7	—	0,06	0,8	1,03
—	0,86	—	0,84	3,2	—	0,04	—	1,5
—	0,83	—	0,97	1,01	—	—	—	0,04
—	—	—	0,69	1,00	—	—	—	—
—	—	—	0,76	0,80	—	—	—	—
—	0,67	—	0,77	0,98	—	—	—	0,1
—	—	—	0,86	0,86	—	—	—	0,09
—	0,84	—	0,80	3,7	—	—	—	0,19
—	—	—	0,88	0,95	—	—	—	—
—	0,77	—	0,81	10,6	—	—	—	0,08
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,68	—	0,75	—	—	—	—	0,03
—	—	—	0,66	2,4	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,85	—	0,64	0,80	—	—	—	0,04
—	—	—	0,87	—	—	—	—	0,04
—	0,68	—	0,79	{ 0,94 2,3	—	0,24	—	2,05
—	1,05	2,7	0,93	{ 0,95 1,9	—	0,04	—	0,12

TABLE IX.

No.	Date. 1900.		Time of occurrence. (1st N. J. T.)			Duration of Total eqke.	P. T.	P. P.
			h	m	s	m s	m s	m s
247	Aug.	27	4.	32.	35 p.m.	3. 20	0. 06	0. 08
256	Sept.	10	9.	39.	50 p.m.	2. 04	0. 10(?)	—
276*	Oct.	9	1.	40.	03 a.m.	2. 08	0. 09	0. 49
280*	„	11	4.	03.	44 a.m.	4. 48	0. 06	1. 10
331*	Nov.	9	10.	32.	21 p.m.	3. 05	—	—
336*	„	10	2.	15.	18 p.m.	1. 59	—	—
338*	„	11	1.	10.	10 a.m.	3. 01	0. 08	—
344	„	13	6.	15.	27 a.m.	2. 49	0. 17	1. 12
351*	„	14	7.	18.	31 p.m.	4. 12	0. 10	0. 51
352*	„	15	3.	13.	25 a.m.	Short	—	—
353*	„	„	3.	16.	56 a.m.	„	—	—
356	„	„	8.	05.	33 a.m.	4. 23	0. 18	1. 26
358	„	„	10.	53.	35 p.m.	5. 28	0. 12(?)	1. 07
362	„	19	4.	55.	33 p.m.	3. 41	0. 11	0. 37
367†	„	28	2.	43.	12 a.m.	1. 00	—	—
370†	Dec.	2	5.	27.	37 a.m.	2. 28	0. 15	—
377*	„	17	0.	59.	35 a.m.	1. 23	—	0. 14
378†	„	„	9.	28.	02 a.m.	2. 09	0. 06	0. 15
382†	„	19	9.	25.	50 p.m.	3 50	0. 13	1. 16
384*	„	29	3.	32.	51 p.m.	4. 20	—	—

(Continued.)

Average period in					Max. range of motion in			
P. T.		P. P.		E. P.	P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick. waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	mm	mm	mm	mm
—	0,61	—	0,95	0,89	—	0,06	—	0,16
—	—	—	0,83	—	—	—	—	—
—	—	—	0,86[1]	—	—	—	—	0,06
—	—	—	0,81	0,97	—	—	—	0,18
—	—	—	0,97	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,95	—	—	—	—	0,04
—	—	8,0	0,88	5,8	—	—	—	0,08
—	—	—	1,03	5,3	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,93	—	—	—	—	0,06
—	1,02	—	0,91	0,87	—	—	—	0,24
—	—	—	0,90	1,08	—	—	—	0,06
—	—	—	—	—	—	—	—	0,11
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,77	—	—	—	—	0,06
—	0,86	—	0,92	—	—	—	—	0,06
—	—	—	—	—	—	—	—	—

TABLE X. LOCAL UNFELT EARTHQUAKES, SEISMOGRAPHS.

No.	Date. 1900.		Time of occurrence (1st N. J. T.)			Duration of Total eqke.	P. T.	P. P.
			h	m	s	m s	m s	m s
5	Jan.	15	10.	32.	12 a.m.	9. 00	1. 18	2. 00
16	„	27	0.	6.	4 a.m.	1. 38	0. 7	—
26	Feb.	9	3.	13.	59 p.m.	1. 9	1. P. T.:— 0. 8 2. P. T.:— 0. 8	0. 16
27	„	12	7.	37.	43 a.m.	2. 45	0. 5	0. 8
29	„	13	2.	26.	16 p.m.	0. 53	—	—
31	„	„	6.	16.	31 p.m.	0. 57	—	—
32	„	„	7.	53.	36 p.m.	1. 22	—	—
33	„	„	9.	46.	42 p.m.	1. 35	—	—
34	„	14	10.	44.	20 a.m.	0. 54	0. 10	—
36	„	„	9.	34.	14 p.m.	0. 34	—	—
48	March	3	1.	47.	58 p.m.	1. 18	—	—
49	„	„	4.	27.	33 p.m.	2. 50	—	—
51	„	4	3.	18.	5 p.m.	1. 30	0. 25	—
55	„	9	10.	57.	52 a.m.	3. 38	0. 21	0. 7
58	„	12	9.	51.	58 a.m.	4. 00	0. 25	—
68	„	18	6.	17.	32 p.m.	5. 20	—	—
72	„	26	9.	40.	5 p.m.	2. 52	0. 9	0. 10
81	April	22	11.	36.	45 a.m.	2. 51	0. 12	—
82	„	„	0.	52.	49 p.m.	1. 21	—	—
83	„	„	2.	13.	39 p.m.	2. 30	—	—
84	„	„	5.	43.	48 p.m.	0. 47	—	—
88	„	27	8.	12.	46 a.m.	2. 3	—	—
89	„	„	9.	23.	22 a.m.	0. 22	—	—
90	„	„	11.	18.	42 a.m.	1. 47	—	—
91	„	„	0.	10.	16 p.m.	3. 35	0. 12	1. 12

NOWHERE RECORDED BY GRAY-MILNE TYPE (Group VIII, B.)

Average period in					Max. range of motion in			
P. T.		P. P.		E. P.	P. T.		P. P.	
Slow. waves.	Quick waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	mm	s	mm	mm
—	—	6,1	—	—	—	—	0,16	—
—	—	—	0,78	—	—	—	—	—
—	0,62 / 1,17	—	0,65 / 1,18	—	—	—	—	—
—	—	—	—	—	—	—	—	0,07
—	—	—	0,41	—	—	—	—	—
—	—	—	0,36	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,39	—	0,33	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,97	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	1,00	—	1,14	1,00	—	—	—	0,04
—	—	—	0,99	—	—	—	—	—
—	—	—	0,96	—	—	—	—	—
—	—	—	0,90	0,95	—	—	—	0,11
—	—	—	1,04	—	—	—	—	0,05
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,67	—	0,86	—	—	—	—	0,01

TABLE X.

No.	Date. 1900.		Time of occurrence. (1st N. J. T.)			Duration of Total eqke.	Duration of P. T.	Duration of P. P.
			h	m	s	m s	m s	m s
93	April	28	2.	12.	8 p.m.	0. 32	0. 2(?)	—
94	„	„	3.	16.	39 p.m.	0. 28	0. $2\frac{4}{10}$	—
95	„	„	6.	24.	12 p.m.	—	—	—
96	„	„	7.	7.	26 p.m.	0. 48	0. 4	—
100	May	5	11.	45.	16 p.m.	6. 20	1. P. T.:— 0. 29 2. P. T.:— 0. 29	1. 12
102	„	12	9.	47.	50 a.m.	1. 43	—	—
103	„	„	5.	37.	47 p.m.	1. 4	—	—
108	„	16	10.	43.	42 p.m.	—	—	—
115	„	27	1.	59.	50 a.m.	5. 00	0. 17	—
123	June	7	1.	50.	43 a.m.	1. 30	0. 16	—
132	„	13	1.	56.	9 p.m.	—	—	—
133	„	„	3.	5.	20 p.m.	0. 27	—	—
134	„	„	4.	42.	59 p.m.	1. 00	—	—
139	„	25	7.	55.	26 a.m.	7. 5	1. P. T.:— 0. 12 2. P. T.:— 0. 12	1. 6
140	„	„	9.	24.	3 a.m.	11. 20	0. 15	1. 17
141	„	„	9.	44.	33 a.m.	2. 11	0. 8	—
142	„	„	10.	14.	49 a.m.	0. 24	—	—
143	„	„	10.	20.	33 a.m.	0. 55	—	—
144	„	„	11.	56.	9 a.m.	13. 5	1. P. T.: 0. 7 2. P. T.:— 0. 8	1. 7
145	„	„	3.	17.	4 p.m.	9. 10	0. 37	1. 43
146	„	„	4.	9.	2 p.m.	1. 7	—	—
147	„	„	4.	53.	37 p.m.	1. 26	—	—
148	„	„	4.	54.	29 p.m.	5. 40	—	0. 45
149	„	„	5.	25.	31 p.m.	2. 37	0. 6	—
150	„	„	5.	46.	43 p.m.	0. 18	—	—

(*Continued.*)

Average period in					Max. range of motion in			
P. T.		P. P.		E. P.	P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	mm	mm	mm	mm
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,90	6,8	0,79	—	—	0,02	—	0,13
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	3,0	1,05	—	—	—	—	0,03
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,74	—	0,78	1,97	—	0,09	—	0,20
—	—	6,0	0,60	3,2	—	—	—	0,43
—	—	—	0,67	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,59	4,7	0,58	2,8	—	0,09	0,44	0,56
—	0,68	2,1	0,59	2,2	—	0,06	—	0,56
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,64	—	—	—	—	0,08
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—

TABLE X.

No.	Date 1900.		Time of occurrence. (1st N. J. T.)			Duration of Total eqke.	P. T.	P. P.
			h	m	s	m s	m s	m s
151	June	25	6.	9.	27 p.m.	1. 30	—	—
156	„	26	5.	24.	3 a.m.	—	—	—
157	„	„	6.	25.	53 a.m.	—	—	—
158	„	„	10.	55.	27 a.m.	6. 00	—	—
162	„	„	9.	21.	31 p.m.	0. 27	—	—
167	„	27	0.	40.	33 p.m.	2. 56	0. 5(?)	—
168	„	„	2.		p.m.	2. 27	0. 10(?)	—
173	July	3	6.	16.	48 a.m.	4. 56	—	—
174	„	5	3.	19.	33 p.m.	3. 20	—	—
175	„	„	4.	25.	21 p.m.	1. 47	—	—
176	„	8		—	a.m.	1. 27	—	—
178	„	10	9.	39.	41 a.m.	0. 50	—	—
179	„	„	10.	57.	51 p.m.	2. 54	—	0. 23
181	„	13	4.	2.	7 p.m.	3. 14	0. 13	0. 56
182	„	„	5.	39.	24 p.m.	3. 23	0. 10	0. 44
183	„	„	6.	41.	2 p.m.	1. 37	—	—
185	„	„	7.	23.	23 p.m.	3. 5	0. 5(?)	0. 40
186	„	„	7.	38.	8 p.m.	1. 50	—	—
192	„	14	8.	40.	23 a.m.	2. 5	—	—
193	„	„	1.	58.	5 p.m.	1. 42	—	—
194	„	„	2.	44.	50 p.m.	1. 9	—	—
195	„	„	3.	4.	35 p.m.	2. 19	—	—
196	„	„	3.	51.	10 p.m.	0. 55	—	—
197	„	„	5.	24.	50 p.m.	1. 19	—	—
198	„	„	5.	27.	6 p.m.	1. 44	—	—
199	„	„	10.	23.	28 p.m.	1. 00	—	—
200	„	15	2.	13.	13 a.m.	5. 30	0. 22	1. 14
202	„	16	9.	27.	54 a.m.	Short	—	—
204	„	„	9.	41.	15 a.m.	„	—	—
205	„	17	0.	49.	59 p.m.	10. 00	1. P.T:— 0. 5 2. P.T:— 0. 6	1. 10

(Continued.)

Average period in					Max. range of motion in			
P. T.		P. P.		E. P.	P. T.		P. P.	
Slow waves.	Quick. waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	mm	mm	mm	mm
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,98	—	—	—	—	—
—	—	—	0,86	—	—	—	—	0,04
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,96	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,83	0,91	—	—	—	0,02
—	0,65	—	0,83	0,97	—	—	—	0,06
—	0,78	—	0,88	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	0,88	1,05	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	1,05	5,9	1,17	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,87	3,3	0,93	{ 3,8 6,6	—	—	0,11	—

TABLE X.

No.	Date. 1900.		Time of occurrence. (1st N. J. T.)			Duration of Total eqke.	Duration of P. T.	Duration of P. P.
			h	m	s	m s	m s	m s
206	July	17	3.	30.	56 p.m.	2. 20	—	—
210	"	24	1.	33.	10 p.m.	0. 58	—	—
211	"	"	9.	32.	24 p.m.	0. 58	—	—
215	"	25	9.	00.	44 a.m.	Short	—	—
216	"	"	10.	00.	31 a.m.	"	—	—
217	"	23	7.	34.	26 a.m.	9. 20	0. 18	1. 30
228	August	4	5.	55.	15 a.m.	—	—	—
234	"	13	2.	16.	40 a.m.	1. 45	—	—
235	"	"	2.	42.	19 a.m.	1. 30	—	—
242	"	25	11.	38.	52 p.m.	2. 38	0. 14	0. 18
243	"	26	9.	7.	34 p.m.	—	—	—
248	"	28	7.	3.	6 p.m.	1. 15	—	—
251	Sept.	1	11.	16.	18 a.m.	3. 30	0. 16	—
254	"	10	4.	45.	33 p.m.	3. 30	0. 16	–
261	"	19	4.	—	p.m.	2. 23	0. 14	—
264	"	26	5.	52.	27 p.m.	1. 31	—	—
265	"	29	2.	38.	14 p.m.	2. 4	0. 12	0. 54
267	Oct.	2	2.	14.	29 a.m.	1. 53	0. 12	—
275	"	8	11.	42.	49 p.m.	2. 7	0. 9	0. 50
281	"	11	6.	26.	43 p.m.	2. 6	—	0. 56
282	"	12	4.	3.	47 a.m.	5. 00	0. 6	1. 13
283	"	13	8.	1.	38 a.m.	17. 20	0. 33	6. 12
285	"	16	8.	38.	29 p.m.	2. 1	0. 18	0. 38
287	"	19	11.	48.	31 a.m.	2. 30	—	– –
289	"	26	0.	28.	52 p.m.	9. 34	0. 11(?)	—
290	"	27	2.	58.	45 a.m.	6. 37	0. 22	1. 50
343	Nov.	13	6.	12.	49 a.m.	1. 45	—	—
349	"	14	2.	0.	4 p.m.	11. 40	—	—
350	"	"	3.	33.	43 p.m.	0. 57	—	—
357	"	15	7.	40.	18 p.m.	4. 17	0. 5	—

(*Continued.*)

Average period in					Maximum range of motion in			
P. T.		P. P.		E. P.	P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	mm	mm	mm	mm
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,89	9,9	0,91	{ 2,9 / 5,4 }	—	—	0,09	—
—	—	10,3	—	—	—	—	0,02	—
—	—	6,0	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,78	{ Init. vib. / 1,02 }	0,43	0,85	—	—	0,12	0,09
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	0,68	—	0,81	0,85	—	—	—	0,04
—	—	—	1,00	—	—	—	—	—
—	—	—	0,83	—	—	—	—	0,06
—	—	—	0,93	—	—	—	—	—
—	—	—	1,03	1,09	—	—	—	0,14
—	0,77	13,7	0,93	—	—	—	0,09	—
—	—	—	0,97	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	{ 2,0 / 5,6 }	0,81	—	—	—	—	—
—	—	—	0,88	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	8,3	1,00	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	10,3	0,92	—	—	—	—	—

TABLE X.

No.	Date. 1900.	Time of occurrence. (1st N. J. T.)	Duration of Total eqke.	Duration of P. T.	Duration of P. P.
		h m s	m s	m s	m s
354	Nov. 15	3. 24. 33 a.m.	2. 40	—	—
359	„ 16	9. 18. 15 a.m.	4. 23	0. 21	2. 14
360	„ „	9. 32. 53 a.m.	3. 18	—	3 18
361	„ 17	6. 56. 35 a.m.	7. 00	—	—
364	„ 20	9. 24. 34 p.m.	5. 00	—	—
374	Dec. 4	1. 12. 20 a.m.	3. 56	0. 19	—
381	„ 19	8. 53. 10 a.m.	5. 51	0. 28	0. 42
385	„ 30	0. 26. 26 a.m.	1. 24	—	0. 17

(*Continued.*)

Average period in					Maximum range of motion in			
P. T.		P. P.		E. P.	P. T.		P. P.	
Slow waves.	Quick waves.	Slow waves.	Quick waves.		Slow waves.	Quick waves.	Slow waves.	Quick waves.
s	s	s	s	s	mm	mm	mm	mm
—	—	—	—	—	—	—	—	—
—	—	26,8	0,89	—	—	—	0,03	—
—	—	9,4	0,93	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—
—	—	—	1,03	—	—	—	—	—
—	0,79	—	0,76	—	—	—	—	—
—	—	—	0,70	—	—	—	—	—

TABLE XII.

LIST OF THE EARTHQUAKES OBSERVED BY THE GRAY-MILNE SEISMOGRAPH AT THE CENTRAL METEOROLOGICAL OBSERVATORY.* 1900, TŌKYŌ.

2a = Range of motion (Double amplitude)
T = Complete period of vibration.

Month.	Day.	Time of occurrence.	Duration.	Direction.	Max. Hor. Mot. T.	Max. Hor. Mot. 2a	Max. Vert. Mot. T.	Max. Vert. Mot. 2a	Intensity.	Remarks.
			m. s.		sec.	mm	sec.	mm		
I.	15	0. 33. 5 p.m.	—	—	—	—	—	—	Slight. *	
	17	0. 14. 12 a.m.	2. 25	ENE WSW.	0.5	0.7	0.7	0.2	,,	The max. horizontal and the vertical movements took place respectively 11 and 15 sec. after the commencement. The duration of the vertical motion was 98 sec.
	18	4. 26. 24 p.m.	—	—	—	—	—	—	,,	
	,,	4. 45. 2 ,,	—	—	—	—	—	—	,, *	
	21	6. 29. 10 ,,	1. 30	WNW ESE.	0.3	0.8	—	—	Weak.	The vertical motion lasted about 12 sec.
	27	0. 16. 13 a.m.	—	—	—	—	—	—	Slight. *	
	31	2. 37. 45 ,,	—	—	—	—	—	—	,,	
II.	1	4. 24. 10 ,,	—	—	—	—	—	—	,,	The motion was gentle.
	7	9. 54. 41 ,,	—	—	—	—	—	—	,, *	
	,,	10. 10. 12 ,,	—	—	—	—	—	—	,, *	
	9	6. 39. 00 ,,	—	—	—	—	—	—	,, *	
	12	7. 37. 41 ,,	—	—	—	—	—	—	,,	
	13	1. 28. 19 p.m.	—	—	—	—	—	—	,, *	
	15	8. 30. 36 ,,	—	—	—	—	—	—	,, *	
	16	9. 10. 28 a.m.	—	—	—	—	—	—	,, *	
	,,	10. 53. 2 ,,	—	—	—	—	—	—	,, *	
	,,	4. 35. 4 p.m.	—	—	—	—	—	—	,, *	
	17	0. 54. 48 ,,	1. 12	WSW ENE.	0.2	0.3	0.1	0.1	,,	The horizontal motion was active for about 10 sec. The vertical motion lasted about 1m 10s.
	18	2. 47. 2 a.m.	—	—	—	—	—	—	,, *	
	,,	8. 4. 30 ,,	—	—	—	—	—	—	,, *	

* Those marked with *asterisks* are slight *unfelt* earthquakes.

1900.

Month.	Day.	Time of occurrence.	Duration.	Direction.	Max. Hor. Mot. T.	Max. Hor. Mot. 2a	Max. Vert. Mot. T.	Max. Vert. Mot. 2a	Intensity.	Remarks.
			m. s.		sec.	mm	sec.	mm		
II	20	11. 51. 00 p.m.	—	—	—	—	—	—	Slight	
	24	9. 21. 4 ,,	—	—	—	—	—	—	,,	*
	25	11. 34. 24 a.m.	—	—	—	—	—	—	,,	
III	1	7. 32. 7 ,,	—	—	—	—	—	—	,,	*
	,,	8. 19. 28 ,,	—	—	—	—	—	—	,,	*
	,,	8. 25. 49 ,,	—	—	—	—	—	—	,,	*
	,,	10. 9. 00 p.m.	—	—	—	—	—	—	,,	*
	4	11. 58. 4 a.m.	3. 23	E-W.	0,4	0,4	—	—	Weak	The prel. tremor lasted about 11 sec., the motion being active for the next 1m 30s.
	,,	3. 18. 27 p.m.	—	—	—	—	—	—	Slight	*
	,,	4. 46. 53 ,,	—	—	—	—	—	—	,,	
	7	7. 16. 13 ,,	—	—	—	—	—	—	,,	*
	8	9. 48. 55 a.m.	—	—	—	—	—	—	,,	*
	9	6. 1. 29 p.m.	—	—	—	—	—	—	,,	
	12	10. 35. 38 a.m.	6. 50	NE-SW.	—	—	—	—	Weak	
	,,	1. 41. 41 p.m.	—	—	—	—	—	—	Slight	*
	,,	7. 57. 7 ,,	—	—	—	—	—	—	,,	*
	13	1. 10. 12 a.m.	—	—	—	—	—	—	,,	*
	,,	6. 53. 32 ,,	—	—	—	—	—	—	,,	*
	14	11. 55. 55 p.m.	—	—	—	—	—	—	,,	
	15	6. 23. 20 ,,	—	—	—	—	—	—	,,	
	16	10. 2. 91 ,,	1. 45	NE-SW.	0,1	0,4	—	—	Weak	
	17	1. 39. 23 ,,	—	—	—	—	—	—	Slight	*
	22	0. 56. 25 a.m.	—	—	—	—	—	—	,,	*
	26	5. 32. 21 p.m.	—	—	—	—	—	—	,,	*
	,,	8. 52. 35 ,,	—	—	—	—	—	—	,,	
	,,	9. 33. 15 ,,	—	—	—	—	—	—	,,	*
IV	15	7. 50. 32 a.m.	—	—	—	—	—	—	,,	
	20	9. 9. 23 p.m.	—	—	—	—	—	—	,,	
	25	8. 19. 10 a.m.	—	—	—	—	—	—	,,	*
V	5	9. 22. 49 ,,	—	—	—	—	—	—	,,	*

1900.

Month.	Day.	Time of occurrence.	Duration.	Direction.	Max. Hor. Mot.		Max. Vert. Mot.		Intensity.	Remarks.
					T.	2a	T.	2a		
			m s		sec.	mm	sec.	mm		
V	,,	11. 45. 44 p.m.	—	—	—	—	—	—	Slight.	*
	12	2. 24. 10 a.m.	4. 10	NE-SW.	0,8	2,4	—	—	Weak.	The prel. tremor lasted 28 sec., when the motion became suddenly great; the amplitude was moreor less active during 70 sec.
	,,	11. 45. 12 ,,	—	—	—	—	—	—	Slight.	*
	15	7. 13. 2 ,,	2. 10	SW-NE.	0,2	0,9	—	—	Weak.	The prel. tremor lasted 12 sec., when the amplitude became suddenly large; the motion being active for the next 25 sec.
	,,	9. 4. 4 p.m.	—	—	—	—	—	—	Slight.	
	21	8. 29. 26 a.m.	—	—	—	—	—	—	,,	
	24	0. 13. 13 ,,	—	—	—	—	—	—	,,	*
	31	5. 40. 39 ,,	—	—	—	—	—	—	,,	*
	,,	5. 44. 47 p.m.	—	—	—	—	—	—	,,	*
VI	7	1. 51. 12 a.m.	—	—	—	—	—	—	,,	*
	8	5. 27. 20 p.m.	—	—	—	—	—	—	,,	*
	,,	8. 31. 3 ,,	—	—	—	—	—	—	,,	*
	10	7. 29. 25 ,,	—	—	—	—	—	—	,,	*
	16	3. 14. 5 a.m.	—	—	—	—	—	—	,,	*
	20	4. 32. 0 p.m.	—	—	—	—	—	—	,,	*
	24	3. 59. 52 ,,	—	—	—	—	—	—	,,	*
	25	9. 24. 17 a.m.	—	—	—	—	—	—	,,	
	,,	11. 56. 20 ,,	—	—	—	—	—	—	,,	*
	,,	2. 39. 15 p.m.	—	—	—	—	—	—	,,	*
	,,	3. 47. 15 ,,	—	—	—	—	—	—	,,	
	,,	9. 12. 18 ,,	—	—	—	—	—	—	,,	
	,,	10. 28. 14 ,,	—	—	—	—	—	—	,,	*
	,,	11. 14. 24 ,,	—	—	—	—	—	—	,,	*
	26	5. 10. 13 a.m.	—	—	—	—	—	—	,,	*
	,,	5. 24. 51 ,,	—	—	—	—	—	—	,,	*
	,,									
	,,	6. 27. 0 ,,	—	—	—	—	—	—	,,	*
	,,	10. 56. 49 ,,	—	—	—	—	—	—	,,	*
	,,	6. 58. 0 p.m.	—	—	—	—	—	—	,,	
	,,	9. 49. 42 ,,	—	—	—	—	—	—	,,	

1900.

Month.	Day.	Time of occurrence.	Duration.	Direction.	Max. Hor. Mot. T.	Max. Hor. Mot. 2a	Max. Vert. Mot. T.	Max. Vert. Mot. 2a	Intensity.	Remarks.
			m. s.		sec.	mm	sec.	mm		
VI.	26	10. 20. 49 p.m.	—	—	—	—	—	—	Slight.	*
	27	0. 54. 4 a.m.	—	—	—	—	—	—	"	*
	"	0. 41. 47 p.m.	—	—	—	—	—	—	"	*
	30	2. 51. 21 "	—	—	—	—	—	—	"	*
VII.	2	5. 38. 35 "	—	—	—	—	—	—	"	*
	7	7. 15. 25 a.m.	—	—	—	—	—	—	"	*
	8	11. 47. 14 "	—	—	—	—	—	—	"	
	10	11. 43. 43 p.m.	—	—	—	—	—	—	"	*
	13	5. 0. 43 "	—	—	—	—	—	—	"	*
	"	7. 19. 52 "	—	—	—	—	—	—	"	*
	"	10. 23. 29 "	—	—	—	—	—	—	"	*
	14	7. 20. 48 a.m.	—	—	—	—	—	—	"	*
	"	8. 11. 41 "	—	—	—	—	—	—	"	*
	"	8. 24. 14 "	—	—	—	—	—	—	"	*
	16	5. 32. 50 p.m.	—	—	—	—	—	—	"	*
	17	11. 52. 4 a.m.	—	—	—	—	—	—	"	*
	20	4. 35. 52 p.m.	—	—	—	—	—	—	"	*
	21	7. 30. 33 a.m.	—	—	—	—	—	—	"	*
	24	9. 52. 40 "	—	—	—	—	—	—	"	*
	25	1. 8. 19 "	—	—	—	—	—	—	"	*
VIII.	4	1. 33. 13 p.m.	—	—	—	—	—	—	"	*
	5	1. 21. 5 "	4. 00.	NNE-SSW.	0,7	1,1	—	—	Weak	The prel. tremor lasted 33sec., the motion becoming then active for 1m.
	8	7. 17. 26 "	—	—	—	—	—	—	Slight.	*
	17	6. 56. 21 a.m.	—	—	—	—	—	—	"	*
	"	5. 27. 56 p.m.	—	—	—	—	—	—	"	*
	25	11. 40. 19 "	—	—	—	—	—	—	"	*
	27	2. 3. 12 a.m.	—	—	—	—	—	—	"	
	"	3. 0. 44 p.m.	50. 00.	NE-SW.	0,2	2,6	0,1	0,5	Weak	The motion was quick and remained active for 20sec.
	"	4. 28. 56 "	—	—	—	—	—	—	Slight.	*
	"	4. 33. 38 "	—	—	—	—	—	—	"	
	29	7. 0. 0 a.m.	—	—	—	—	—	—	"	*

1900.

Month.	Day.	Time of occurrence.	Duration.	Direction.	Max. Hor. Mot. T.	Max. Hor. Mot. 2a	Max. Vert. Mot. T.	Max. Vert. Mot. 2a	Intensity.	Remarks.
			m. s.		sec.	mm	sec.	mm		
VIII.	29	11. 34. 41 a.m.	—	—	—	—	—	—	Slight.	
IX.	1	11. 16. 32 „	—	—	—	—	—	—	„	
	5	6. 3. 32 p.m.	—	—	—	—	—	—	„ *	
	9	0. 31. 36 „	—	—	—	—	—	—	„ *	
	10	9. 31. 34 „	—	—	—	—	—	—	„ *	
	19	4. 23. 3 „	—	—	—	—	—	—	„ *	
	24	0. 36. 24 „	—	—	—	—	—	—	„ *	
X.	3	3. 19. 16 a.m.	1. 18.	WNW-ESE.	0,7	3,0	—	—	Weak.	The prel. tremor lasted 9 sec., when the max. motion suddenly took place. The motion was active for 15 sec.
	3	3. 50. 36 „	—	—	—	—	—	—	Slight. *	
	4	4. 18. 22 p.m.	—	—	—	—	—	—	„ *	
	7	4. 17. 41 a.m.	—	—	—	—	—	—	„ *	
	9	1. 41. 7 „	—	—	—	—	—	—	„	
	12	4. 3. 53 „	—	—	—	—	—	—	„	
	16	0. 28. 5 p.m.	—	—	—	—	—	—	„ *	
XI.	1	9. 50. 26 a.m.	—	—	—	—	—	—	„	
	2	3. 4. 15 p.m.	—	—	—	—	—	—	— *	
	5	8. 15. 13 a.m.	—	—	—	—	—	—	— *	
	„	2. 9. 51 p.m.	—	—	—	—	—	—	—	
	„	4. 41. 37 „	3. 20.	SES-NWN.	0,1	3,3	0,1	1,0	Weak.	The prel. tremor lasted 22 sec., when the amplitude became suddenly large. The max. displacement took place 11 sec. further on, the motion being active for 55 sec. The vertical motion, whose maximum occurred at the same time as the horizontal maximum, lasted 1m 40s.
	„	5. 4. 2 „	—	—	—	—	—	—	Slight. *	
	„	5. 19. 20 „	—	—	—	—	—	—	„	
	„	7. 38. 43 „	—	—	—	—	—	—	„ *	

1900.

Month.	Day.	Time of occurrence.	Duration.	Direction.	Max. Hor. Mot. T.	Max. Hor. Mot. 2a	Max. Vert. Mot. T.	Max. Vert. Mot. 2a	Intensity.	Remarks.
			m. s.		sec.	mm	sec.	mm		
XI	5	9. 18. 10 p.m.	—	—	—	—	—	—	Slight.	*
	,,	9. 45. 37 ,,	—	—	—	—	—	—	,,	*
	6	6. 13. 50 ,,	—	—	—	—	—	—	,,	
	9	5. 45. 33 a.m.	—	—	—	—	—	—	,,	*
	,,	11. 30. 48 ,,	—	—	—	—	—	—	,,	*
	10	2. 55. 26 ,,	2. 40	NEN-SWS.	—	0,9	1,6	—	Weak.	The motion was gentle, and the max. displacement took place at 50 sec. after commencement: the motion being active for 1 m 50 s.
	13	6. 15. 12 ,,	—	—	—	—	—	—	Slight.	*
	,,	6. 32. 7 ,,	—	—	—	—	—	—	,,	*
	15	6. 37. 54 ,,	—	—	—	—	—	—	Weak.	
	,,	8. 6. 7 ,,	—	—	—	—	—	—	Slight.	
	,,	10. 53. 41 p.m.	—	—	—	—	—	—	,,	
	17	7. 1. 7 a.m.	—	—	—	—	—	—	,,	*
	19	4. 56. 6 p.m.	—	—	—	—	—	—	,,	*
	,,	10. 58. 40 ,,	—	—	—	—	—	—	,,	
	24	5. 2. 8 ,,	—	—	—	—	—	—	,,	*
	28	2. 43. 45 a.m.	—	—	—	—	—	—	,,	*
	1	0. 33. 39 p.m.	—	—	—	—	—	—	,,	*
	2	5. 29. 13 a.m.	—	—	—	—	—	—	,,	
	4	10. 11. 18 ,,	—	—	—	—	—	—	,,	*
	6	2. 2. 3 p.m.	—	—	—	—	—	—	,,	*
	9	0. 42. 42 ,,	—	—	—	—	—	—	,,	*
	17	9. 27. 57 a.m.	—	—	—	—	—	—	,,	*
	19	9. 17. 18 p.m.	—	—	—	—	—	—	,,	*
	25	2. 9. 26 ,,	—	—	—	—	—	—	Weak.	*

III. Periods of vibration.

§ 5. *Earthquakes of Group I.* For the sake of convenience, let us first consider the distant earthquakes, namely, those of Group I; the motion in these cases being much simpler than in the earthquakes of near origin, whose distance from the observing station is, say, under 1000 km. (For the discussion of the periods of vibration in *very great* distant earthquakes, the reader is referred to § 39.) The mean values of the different kinds of periods in the successive stages of motion, deduced from 84 earthquakes of Group I, are given in the following table; the figures within brackets indicating the number of cases, from which the respective values of the periods have been found.

TABLE XIII.

PERIODS OF VIBRATION. (GROUP I EARTHQUAKES.)

1st Prel. Tremor.	2nd Prel. Tremor.	Principal Portion.			End Portion.
		1st Phase.	2nd Phase.	3rd Phase.	
sec.	sec.	sec.	sec.	sec.	sec.
1,04(14)	1,03(2)	— —	0,96(3)	1,01(2)	— —
4,6 (26)	5,1 (2)	3,3 (3)	4,1 (2)	5,7 (5)	4,8 (1)
8,7 (28)	**8,5** (14)	8,4 (3)	8,6 (6)	**9,3** (32)	**9,6** (32)
15,0 (8)	**14,8** (8)	— —	**13,6** (9)	**13,6** (22)	**16,0** (12)
— —	— —	— —	**17,8** (12)	18,4 (9)	— —
20,8 (2)	20,3 (3)	**22,9** (5)	**22,3** (9)	— —	22,0 (1)
— —	25,5 (3)	**27,6** (6)	**25,9** (10)	25,8 (1)	— —
— —	32,6 (1)	34,3 (4)	34,3 (2)	— —	— —
— —	— —	43,3 (4)	45,4 (1)	— —	— —
— —	— —	54,0 (2)	— —	— —	— —

In the above table, the corresponding periods in the different portions are placed in the same horizontal rows; the periods most frequently occurring in each portion being printed in fat letters. The averages of the different sets of periods, deduced by taking the means of the different values in the same horizontal rows are given in the following table; the corresponding results for Hongō (Tōkyō) being taken from the observations between July 1898 and Dec. 1899, given in the *Publications*, No. 5, p. 40. The notations P's there employed are the same as those here employed, except for the introduction of P_0, P'_4, and P'_8.

TABLE XIV.

PERIODS OF VIBRATION IN DISTANT EARTHQUAKES.

Hitotsubashi and Hongo.

Hitotsubashi.	Hongo.	Mean.
sec.	sec.	sec.
1,02	——	1,02 = P_0 (for Hitotsubashi only).
4,65	4,56	4,6 = P_1
8,85	8,86	8,9 = P_2
14,4	15,2	14,8 = P_3
18,2	——	18,2 = P'_4
22,0	21,6	21,8 = P_4
26,4	25,1	25,8 = P_5
34,1	31,1	32,6 = P_6
43,7	39,2	41,5 = P_7
54,0	——	54,0 = P'_8
——	66,0	66,0 = P_8

The period P_0 seems to be proper to the soil of Hitotsubashi. All the other periods are, however, not local in character, being nearly equal for Hitotsubashi and Hongō. P_1 occurs most frequently in the 1st preliminary tremor, while P_2 occurs very often in the 1st and the 2nd preliminary tremors, the 3rd phase of the principal portion and in the end portion; P_3 being also most frequent in the same four epochs. The periods P_4', P_4 and P_5 frequently occur in the 1st three phases of the principal portion, while P_6 and P_7 occur almost exclusively in the first two phases of the same portion.

§ 6. *Earthquakes of Groups II to IX.*

In the earthquakes of Groups II to IX, the motion is much complex, owing to the presence of quick vibrations. The following table is a classified list of the different periods occurring in the successive portions of the seismic disturbance.

TABLE XV.

PERIODS OF VIBRATOINS AT HITOTSUBASHI. [EARTHQUAKES OF GROUPS II–IX.]

Group / Eqke motion.	II.	III and IV.	V.	VI and VII.	VIII, A.	VIII, B.
1st and 2nd prel. tremors.	sec. —— **1,09**(10) —— 3,4 (4) 8,1 (3) 12,1 (2) 19,2 (1) ——	sec. 0,61 (1) **0,94** (32) 1,30 (1) 2,6 (9) 10,0 (4) —— —— 24,0 (1)	sec. —— **0,97** (16) 1,45 (1) 3,1 (1) 9,3 (1) —— 17,1 (1) ——	sec. —— **0,97** (7) —— 2,6 (2) 9,1 (2) —— 18,1 (1) —— 4,8 (1)	sec. **0,82** (26) **1,07** (7) —— 2,6 (2) —— —— —— —— 6,5 (1)	sec. **0,73** (13 1,03 (4) —— —— —— —— —— ——
Principal portion.	—— —— —— **1,09** (6) —— 2,8 (5) 4,9 (1) **6,8** (7) 12,5 (4) 18,1 (3) —— —— 29,2 (2)	—— —— **0,90** (29) —— 1,34 (2) **2,74** (8) **4,6** (11) 7,2 (6) 10,2 (4) 15,7 (2) 20,7 (4) 25,7 (1) ——	—— —— **0,96** (25) —— 1,22 (5) 2,0 (3) 4,4 (2) **7,68** (12) **12,0** (12) 17,2 (1) 22,0 (1) 27,6 (1) ——	—— —— **0,98** (8) —— 1,4 (1) 2,3 (3) 4,1 (4) **8,2** (8) —— 16,5 (3) 23,8 (2) —— 30,6 (1)	—— —— **0,84** (52) 1,09 (7) —— 2,8 (6) 4,3 (3) 8,7 (5) —— —— —— —— ——	0,38 (4) 0,61 (5) **0,86** (23) **1,03** (15) —— 2,6 (4) 5,9 (7) —— 10,3 (6) —— —— 26,8 (1) ——
End portion.	—— 2,2 (1) 4,0 (1) —— **8,9** (6) ——	**1,00** (12) 2,7 (4) **4,07** (9) 5,93 (3) **9,11** (7) ——	0,94 (2) —— 3,7 (5) —— **7,9** (13) 11,0 (1)	0,99 (1) —— 4,2 (3) —— **8,0** (6) ——	**0,97** (24) 2,4 (6) **3,9** (11) 5,6 (2) 8,9 (2) ——	**0,96** (8) 2,8 (6) —— 6,0 (2) —— ——

The averages of the different periods in the preliminary tremors, the principal portion, and the end portion, are collected in the following table; the resultant values, meaned from all the three epochs of the earthquake motion being denoted by the symbols p_1 p_2 $P_0 \cdots P_6$.

TABLE XVI. MEAN PERIODS OF VIBRATION.
[EARTHQUAKES OF GROUPS II—IX.]

1st and 2nd prel. tremors.	Principal portion.	End portion.	Mean.	
sec.	sec.	sec.	sec.	
——	0,38 (4)	——	0,38 (4)	$=p_1$
——	0,61 (5)	——	0,61 (5)	$=p_2$
0,92 (119)	**0,92** (165)	**0,98** (47)	**0,93** (331)	$=P_0$
1,4 (2)	1,27 (8)	——	1,30 (10)	$=p_3$
2,8 (19)	**2,62** (29)	**2,6** (17)	**2,68** (65)	$=P'_1$
4,8 (1)	**4,8** (28)	**4,4** (36)	**4,58** (65)	$=P_1$
9,0 (11)	**7,7** (38)	**8,4** (34)	**8,17** (82)	$=P_2$
12,1 (1)	**11,4** (26)	11,0 (1)	11,4 (28)	$=P'_2$
18,1 (3)	16,9 (9)	——	17,2 (12)	$=P'_4$
——	21,8 (7)	——	21,8 (7)	$=P_4$
24,0 (1)	26,7 (3)	——	26,0 (4)	$=P_5$
——	29,7 (3)	——	29,7 (3)	$=P_6$

The mean periods, P_0, P_1, P_2, etc., are identical with those occurring in the case of distant earthquakes. Again, of the twelve mean values given in the last column of the above table, the four periods, p_1, p_2, P_0, and p_3, belong to the quicker vibrations, which become, when sufficiently large in amplitude, macroseismic in character; the period occurring most frequently being P_0, (=0,93 sec.). The remaining eight periods P'_1, P_1, $P_2 \ldots P_6$ may be regarded as characterizing slow unfelt movements; the period most frequently occurring being P_2 (=8,17 sec.), and those next frequently occurring being P_1 (=4,58 sec.) and P'_1 (=2,68 sec.). Long periods of 20 to 30 seconds, namely, those of P_4, P_5, and P_6 types, occurred very rarely; this circumstance arising from the fact that the earthquakes of Groups II to IX were mostly small earthquakes.

The four quick periods p_1, p_2, P_0, and p_3, have a mean common difference of 0,31 sec., while the seven slower periods, P_1, P_2, P'_2, P'_4, P_4, P_5 and P_6, have a mean common difference of 3,9 sec.

Comparing together tables XIV and XVI, we see that the slower periods occurring most frequently in earthquakes of distant, as well as near, origins are P_2 and P_1 type vibrations; these being identical with the two predominating periods of the pulsatory oscillations (§ 17).

IV. Constancy of the different periods of vibration in the 1st and the 2nd preliminary tremors of the earthquakes of group I.

§ 7. Table XVII gives the period of vibrations in the 1st and the 2nd preliminary tremors of distant earthquakes, (Group I), arranged according to the duration of the total preliminary tremor and divided into a convenient number of groups.

TABLE XVII.

CONSTANCY OF THE DIFFERENT PERIODS IN DISTANT EARTHQUAKES.

Eq. No.	Duration of total prel. tremor.	Average periods in 1st and 2nd prel. tremors.
	m. s.	sec. sec. sec. sec.
211	0. 37	— ; 8.3 ; — ; —
369	0. 40	— ; 9.9 ; — ; —
368	1. 18	— ; 7.7 ; — ; —
17	1. 21	— ; — ; 15.8 ; —
210	1. 22	4.6 ; — ; — ; —
Mean	**1. 4**	**4.6 ; 8.6 ; 15.8 ; —**
380	2. 30	3.7 ; — ; — ; 27.4
362	3. 9	3.7 ; 8.1 ; — ; 38.0
238	3. 29	4.2 ; — ; — ; —
22	3. 52	— ; — ; 14.5 ; —
Mean	**3. 15**	**3.9 ; 8.1 ; 14.5 ; 27.4 / 38.0**
263	4. 00	5.4 ; — ; — ; —
237	4. 50	3.8 ; 8.3 ; — ; —
28	5. 16	4.1 ; 10.3 ; — ; —
168	6. 13	— ; 10.0 ; — ; —
156	6. 16	5.2 ; 9.2 ; — ; —
285	6. 17	— ; 9.0 ; — ; —
Mean	**5. 29**	**4.6 ; 9.4 ; — ; —**
111	7. 30	4.0 ; 7.8 ; — ; —
2	7. 38	— ; — ; 15.9 ; —
167	8. 0	3.9 ; — ; — ; —
377	8. 38	5.1 ; — ; — ; —
259	8. 40	5.3 ; 9.3 ; — ; —
94	8. 44	4.8 ; — ; — ; —
Mean	**8. 12**	**4.6 ; 8.6 ; 15.9 ; —**
256	9. 4	3.8 ; 8.0 ; 15.2 ; —
20	9. 28	— ; — ; 13.6 ; —
134	9. 30	5.9 ; — ; — ; —
376	9. 30	— ; 9.5 ; — ; —
Mean	**9. 23**	**4.9 ; 8.8 ; 15.9 ; —**
	m. s.	sec. sec. sec. sec.
338	10. 10	— ; 9.6 ; — ; —
269	10. 55	4.7 ; 9.8 ; — ; 25
266	11. 6	4.7 ; — ; — ; —
Mean	**10. 44**	**4.7 ; 9.7 ; — ; 25**
215	12. 22	4.8 ; 10.2 ; — ; 20.5 / 26.8
274	12. 27	4.8 ; 7.8 ; 14.2 ; 19.6 ; 24.8
1	12. 52	— ; 7.2 ; 13.0 ; —
13	12. 52	4.9 ; 10.2 ; — ; —
224	13. 00	4.7 ; 8.3 ; — ; —
Mean	**12.43**	**4.8 ; 8.7 ; 13.6 ; 20.1 / 25.8**
266	14. 43	— ; 8.8 ; — ; —
270	15. 3	5.1 ; 8.6 ; — ; 21.2
8	15. 5	— ; — ; 11.8 ; —
126	15. 2	5.4 ; — ; — ; —
218	15. 10	4.5 ; 8.8 ; — ; —
54	15. 16	4.1 ; 7.5 ; 13.4 ; —
119	16. 50	— ; — ; 14.4 ; —
Mean	**15. 19**	**4.8 ; 8.4 ; 13.2 ; 21.2**
275	20. 40	— ; 10.2 ; — ; —
285	20. 56	— ; 8.1 ; 14.6 ; —
11	21. 40	5.3 ; 7.3 ; 14.7 ; —
288	32. 31	— ; 7.6 ; — ; 32.6
133	33. 30	5.8 ; 8.9 ; 16.0 ; 20.0
Mean	**25. 51**	**5.6 ; 8.4 ; 15.0 ; 20.0 / 32.6**

The mean results obtained from the above table are as follows.

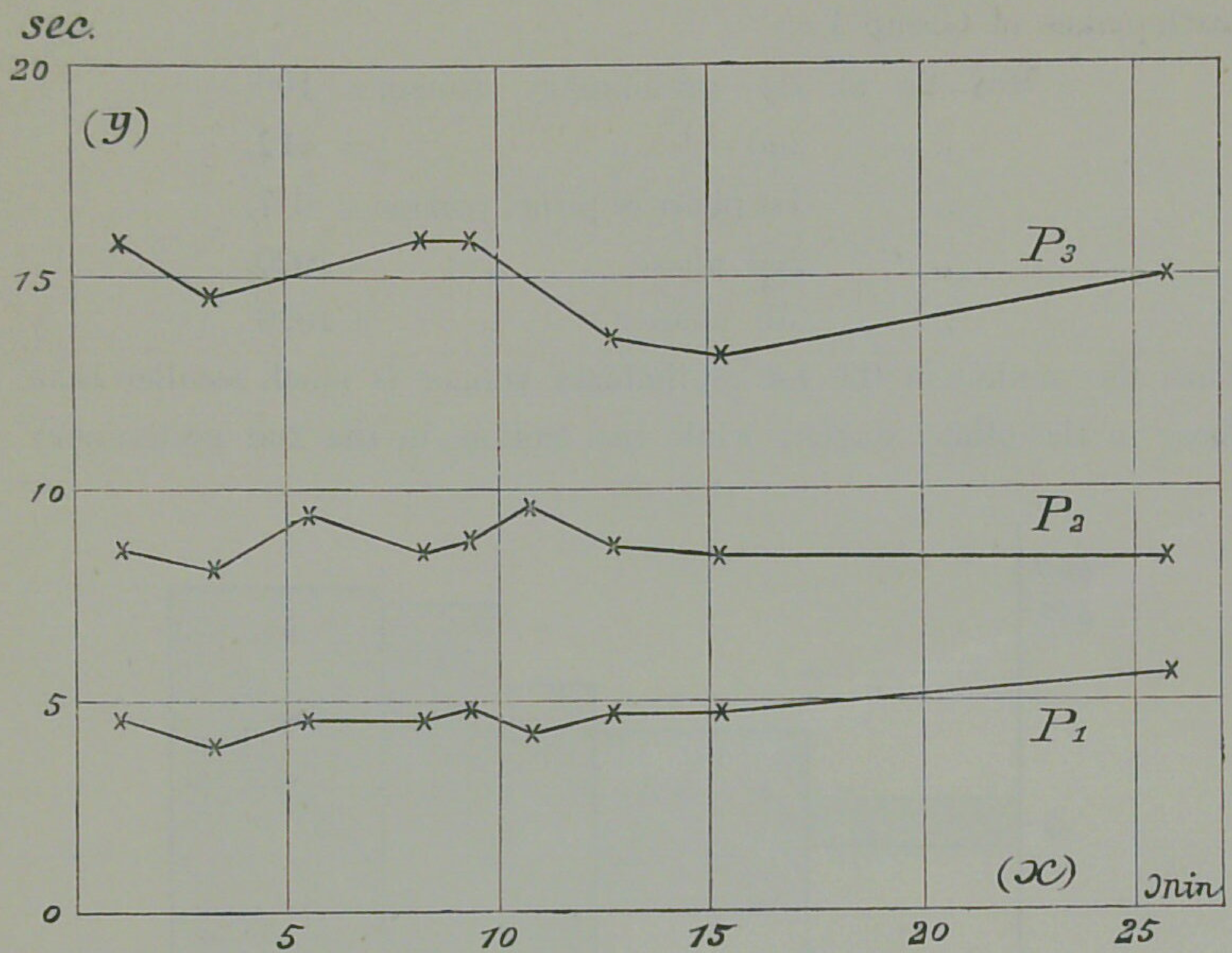
TABLE XVIII.

CONSTANCY OF THE DIFFERENT PERIODS IN DISTANT EARTHQUAKES. (*Continued*).

Duration of the total prel. tremor.		Periods.					
		P_1	P_2	P_3	P_4	P_5	P_6
m	s	sec.	sec.	sec.	sec.	sec.	sec.
1	4	4,6	8,6	15,8	——	——	——
3	15	3,9	8.1	14,5	——	27,4	38,0
5	29	4,6	9,4	——	——	——	——
8	12	4,6	8,6	15,9	——	——	——
9	23	4,9	8,8	15,9	——	——	——
10	44	4,7	9,7	——	——	25,0	——
12	43	4,8	8,7	13,6	20,1	25,8	——
15	19	4,8	8,4	13,2	21,2	——	——
25	51	5,6	8,4	15,0	20,0	——	32,6

Thus it will be seen that, in cases of distant earthquakes, the different periods, P_1, P_2, P_3, etc., of the vibrations in the 1st and the 2nd preliminary tremors do not depend on the duration of the latter that is to say, on the distance of the earthquake origin from the observing station. (See Fig. 2.) Similar conclusion probably holds goods also for the periods in other stages of the earthquake motion. The cases of macro-seismic movements have already been discussed in the *Publications* No. 11, where it was shown that different periods varying from fractions of a second to some 2 seconds do not depend on the distance of the origin or the size of the earthquake.

Fig. 2.



x = Duration of total preliminary tremor.
y = Period of vibration.

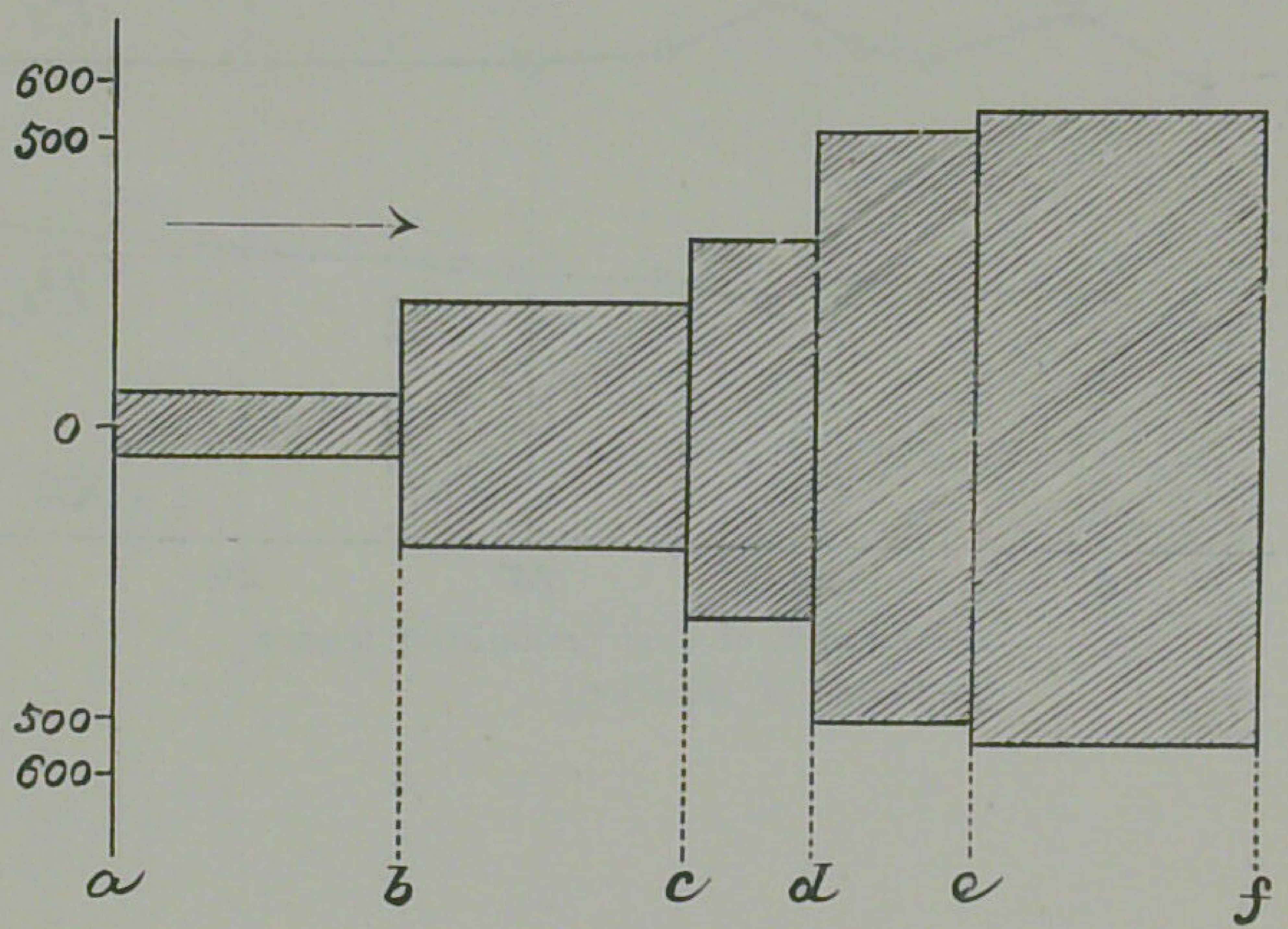
V. Relative Magnitudes of the Maximum Movements in the Different Stages of the Earthquake Motion.

§ 8. (a) *Distant earthquakes observed at Hitotsubashi.* The 1st and the 2nd preliminary tremors and the successive parts of the principal portion of the earthquake motion are characterized by the difference of amplitude as well as by that of period. The following mean values of the relative magnitudes of the maximum motions in the different stages of the motion have been deduced from the 84 earthquakes of Group I:—

Max. 2a in 1st preliminary tremor = 100,
,, 2nd ,, ,, = 412,
,, 1st phase of princ. portion = 647,
,, 2nd phase ,, = 1020,
,, 3rd phase ,, = 1090.

Thus the motion in the 1st preliminary tremor is much smaller than those in the other stages; while the motion in the 2nd preliminary

Fig. 3.



ab........1st Prel. Tremor.
bc........2nd ,, ,,
cd........1st phase of Princ. Portion.
de........2nd ,, ,, ,,
ef........3rd ,, ,, ,,

tremor does not much differ from that in the 1st phase of the principal portion. The motion is greatest and nearly equal in the 2nd and 3rd phases of the latter portion.

(b) *Distant earthquakes observed at Hongō.* For the sake of reference, I give here the mean values of the relative magnitudes of the maximum movements in the different stages of the distant earthquakes observed at Hongō in 1898-1899 (the *Publications*, No 5):—

Max. 2a in	1st preliminary tremor	= 100,
,,	2nd ,, ,,	= 613,
,,	1st phase of princ. portion	= 1290,
,,	2nd phase ,,	= 1720,
,,	3rd phase ,,	= 550.

These results for Hongō are to be regarded as being only approximate, the data utilized being less complete than those for Hitotsubashi, considered above.

§ 9. *Earthquakes of Groups II—VIII, observed at Hitotsubashi.*

The following table gives, for the different earthquakes of comparatively near origin, or those of Groups II to VIII, the maximum range of motion in the preliminary tremor and that in the principal portion, arranged according to the magnitude of the former and conveniently divided into groups.

TABLE XIX.

MAX. 2a IN THE PREL. TREMOR AND THE PRINCIPAL PORTION. GROUPS II—VIII.

Eq. No.	Max. 2a in Prel. tremor. (mm)		Max. 2a in Princ. Portion. (mm)	
18	0,01		0,31	
100	0,02		0,13	
263	0,03		0,30	
37	0,04	*Mean* **0,03**	0,44	*Mean* **0,48**
66	0,04		0,30	
180	0,04		1,50	
247	0,04		0,12	
14	0,06		0,80	
70	0,06		0,40	
177	0,06		1,03	
247	0,06	*Mean* **0,06**	0,16	*Mean* **0,56**
145	0,06		0,56	
70	0,06		0,40	
139	0,09		0,20	
144	0,09		0,56	
69	0,10	*Mean* **0,10**	0,65	*Mean* **0.59**
160	0,10		0,66	
106	0,11		0,90	
50	0,19		0,70	
59	0,31	*Mean* **0,27**	1,80	*Mean* **1,40**
245	0,24		2,05	
77	0,33		1,03	
230	0,90		3,90	

Thus it will be seen that a large motion in the preliminary tremor always corresponds to a large motion in the principal portion. This result has a practical importance, because we are, by the observation of the commencement of an earthquake, enabled to foretell at once the relative magnitude of the subsequent motion. The discussion of this point in cases of strong macro-seismic motion shall be reserved for another occasion.

VI. Relative Magnitudes of the Quick and the Slow Vibrations occurring in an earthquake.

§ 10. The following table gives the maximum ranges of motion (double amplitude) of the quick and the slow vibrations occurring in the different earthquakes of Groups II—IX; *quick vibrations* meaning those whose period is less than, or about equal to 1 sec., and *slow vibrations* those whose period is much longer and amounts to several seconds.

TABLE XX.

RELATIVE MAGNITUDES OF QUICK AND SLOW VIBRATIONS. GROUPS II—VIII.

Group.	Eqke No.	Max. 2a of slow vibration.	Max. 2a of quick vibration.
		mm	mm
II	20	1,70	0,38
III	59	3,10	1,80
	62	0,06	0,04
	67	0,09	0,04
	101	10,90	7,00
	118	0,04	0,04
	230	5,90	3,90
	263	0,21	0,30
	375	0,06	0,09
VI	257	0,13	0,17
		mm	mm
Mean	—	**2,22**	**1.38**
IV	160	0,56	0,66
	229	0,31	0,70
V	303	2,70	0,38
	309	0,16	0,25
	315	0,18	0,09
	320	0,05	0,02
	323	2,40	0,70
	330	0,24	0,18
	363	0,50	0,44
	368	0,18	0,14
VII	8	1,00	0,68
	69	0,43	0,40
	120	0,08	0,06
	366	0,08	0,03
VIII, A	119	0,13	0,13
	172	0,13	0,16
	177	0,80	1,03
VIII, B	144	0,44	0,56
	242	0,12	0,09
IX	85	0,24	0,48
	86	1,14	0,25
	113	0,13	0,16
		mm	mm
Mean.	—	**0,55**	**0,35**

From the above table, we get the following results, 2a′ and 2a″ denoting respectively the range of motion of the slow vibration and that of the quick one.

Groups II, III and VI (or earthquakes of comparatively distant origin):—

$$\text{Mean } 2a' = 2{,}22 \text{ mm},$$
$$\text{,, } 2a'' = 1{,}38 \text{ ,,}$$
$$\text{Ratio } \frac{2a'}{2a''} = 1{,}6.$$

Groups IV, V, VII, VIII A, VIII B, and IX (or earthquakes of comparatively near origin):—

$$\text{Mean } 2a' = 0{,}55 \text{ mm},$$
$$\text{,, } 2a'' = 0{,}35 \text{ ,,}$$
$$\text{Ratio } \frac{2a'}{2a''} = 1{,}6.$$

Thus it seems that in earthquakes of Groups II—IX, the slow period vibrations are on the whole about 1,6 times greater than the quick period ones.

§ 11. The following examples relate to the Tōkyō observations of three great earthquakes, whose origins were respectively off the north-eastern coast of the Main Island, in the province of Echigo, and off the eastern coast of the province of Kii.

(1). Eqke of April 23,1898; 8.37.00 a.m.:—

$$2a' = \text{about } 23\text{mm}, \quad 2a'' = 2{,}3\text{mm},$$
$$\text{Ratio } \frac{2a'}{2a''} = 10.$$

(2). Eqke of May 26,1898; 3.00.00 a.m.:—

$$\text{(EW component) } 2a' = 30 \text{ mm}, \quad 2a'' = 6{,}1 \text{ mm},$$
$$\text{Ratio } \frac{2a'}{2a''} = 4{,}9.$$
$$\text{(NS component) } 2a' = 13 \text{ mm}, \quad 2a'' = 3{,}1 \text{ mm},$$
$$\text{Ratio } \frac{2a'}{2a''} = 4{,}2.$$

(3). Eqke of March 7,1899; 9.55.29 a.m.:—

$$2a' = 16 \text{ mm}, \; 2a'' = 1{,}2 \text{ mm},$$

$$\text{Ratio } \frac{2a'}{2a''} = 13.$$

The mean of the ratios $\frac{2a'}{2a''}$ is about 9. The distances of the centres of the above three earthquakes from Tōkyō were respectively 400, 140, and 390 km.

The probable conclusion is that, in great earthquakes, the slow period motion would be many times greater than the quick period one. Further, it is to be remembered that quick vibrations diminish much more rapidly than slow ones, as the seismic disturbances spread from the centre, owing to the viscosity of the material forming the earth's crust.

VII. Durations of the 1st and the 2nd Preliminary Tremors.

§ 12. The following table gives the durations of the 1st and 2nd preliminary tremors in the cases of 45 earthquakes observed at Hitotsubashi, in which these two introductory stages of motion were well demarked from each other.

TABLE XXI.

DURATIONS OF THE 1ST AND THE 2ND PRELIMINARY TREMORS.

Group.	Eqke No.	1st P. T.	2nd P. T.
		m s	m s
I	2	7. 24	5. 28
	10	7. 25	7. 40
	13	10. 40	11. 00
	56	8. 00	7. 16
	136	14. 50	18. 40
	209	7. 40	7. 03
	213	0. 41	0. 41
	214	0. 18	0. 19
	218	7. 39	4. 43
	272	5. 55	5. 00
	273	8. 18	6. 45
	277	7. 22	5. 05
	288	9. 56	11. 00
	291	16. 55	15. 36
		m s	m s
	Mean.	**8. 04**	**7. 35**
VIII A	47	0. 07	0. 07
	50	0. 06	0. 06
	119	0. 11	0. 11
	163	0. 06	0. 06
	164	0. 08	0. 08
	177	0. 07	0. 07
	180	0. 04	0. 04
	191	0. 06	0. 06
	246	0. 12	0. 07
VIII B	23	0. 08	0. 08
	100	0. 29	0. 29
	139	0. 12	0. 12
	144	0. 07	0. 08
	205	0. 05	0. 06

Group.	Eqke No.	1st P. T.	2nd P. T.
		m s	m s
III	18	0. 15	0. 18
	37	0. 11	0. 11
	160	0. 06	0. 06
	240	0. 17	0. 13
V	318	0. 11	0. 09
	328	0. 56	0. 43
	363	0. 12	0. 13
IV	59	0. 23	0. 23
	67	0. 35	0. 35
	118	0. 34	0. 26
	121	0. 45	0. 38
	271	0. 37	0. 35
IX	85	0. 19	0. 19
II	20	1. 00	0. 18
	28	1. 03	0. 49
	43	0. 51	0. 51
VI	126	2. 15	2. 00
		m s	m s
	Mean.	**0. 25**	**0. 23**

The mean results are as follows, y_1 and y_2 denoting respectively the durations of the 1st and the 2nd preliminary tremors.

Distant Earthquakes (14 cases):—

$$y_1 = 8 \text{ m } 4 \text{ s},$$

$$y_2 = 7 \text{ m } 35 \text{ s},$$

$$\text{Ratio } \frac{y_1}{y_2} = 1{,}06.$$

Earthquakes of Groups II—IX (31 cases):—

$$y_1 = 25 \text{ s},$$

$$y_2 = 23 \text{ s},$$

$$\text{Ratio } \frac{y_1}{y_2} = 1{,}09.$$

Thus the durations of the two preliminary tremors are found to be nearly identical for distant earthquakes as well as for comparatively near ones; y_1 being, however, slightly greater than y_2. These results are nearly the same as those formerly found. (See the *Publications*, No. 5.)

VIII. The Direction of the First Displacement in the Principal Portion of the Local Earthquakes.

§ 13. The following two tables give the direction of the very first displacement in the *principal portion* of the EW component earthquake motion, whose origin was not far from Tōkyō; only those cases being taken, in which the distinction between the preliminary tremor and the principal portion was well defined. Table XXII relates to the Hitotsubashi observations, while Table XXIII relates to the Hongō observations made in 1898-1899.

TABLE XXII.

INITIAL DIRECTION OF MOTION OF THE PRINCIPAL PORTION. **Hitotsubashi.**

Group.	Eqke No.	Direction.	Group.	Eqke No.	Direction.	Group.	Eqke No.	Direction.
III	45	E	V	363	E	VIII, A	239	E
	59	W		368	E		247	E
	101	W	VIII, A	14	E		280	E
	230	W		41	W		358	E
	355	E		57	W		378	E
IV	37	E		70	W		382	W
	60	W		71	E	VIII, B	55	W
	64	E		77	W		72	W
	138	W		80	E		81	W
	160	E		87	W		93	W
	270	W		99	E		140	W
V	292	E		111	W		144	W
	295	E		128	E		145	E
	301	E		163	E		148	E
	309	E		172	W		181	E
	315	E		180	E		242	W
	316	E		190	W		265	E
	317	E		191	W		275	E
	323	E		204	E		282	E
	328	E		212	E			
	330	E		232	E			

TABLE XXIII.

INITIAL DIRECTION OF MOTION OF THE PRINCIPAL PORTION. **Hongo.**

Group.	Eqke No.	Direction.	Group.	Eqke No.	Direction.	Group.	Eqke No.	Direction.
III	94	E	VIII, a	55	W	VIII, a	159	E
	167	E		67	E		180	E
	176	E		77	E	VIII, c	6	E
VIII, a	7	W		80	E		78	E
	10	E		114	E		101	W
	38	E		124	E		227	E
	46	W		135	E			
	49	E		157	W			

From the above two tables taken together, we obtain the following results.

Groups III and IV :—

Initial displacement directed toward E, ...9 cases,
 ,, ,, ,, ,, W, ...6 ,, .

Group V :—

Initial displacement directed toward E, ...12 cases,
 ,, ,, ,, ,, W, ...0 ,, .

Group VIII, A :—

Initial displacement directed toward E, ...29 cases,
 ,, ,, ,, ,, W, ...15 ,, .

Group VIII, B :—

Initial displacement directed toward E, ... 4 cases,
 ,, ,, ,, ,, W, ...9 ,, .

Thus it will be seen that in earthquakes of Groups III, IV and VIII A, the displacement in question is, in majority of cases, directed toward E; while in earthquakes of Group V, it is *always* toward the same direction. In earthquakes of Group VIII B, however, the direction was oftener toward W than toward E. These facts seem to indicate that the direction of the first displacement of the principal portion at a given station is generally determined by the position of the seismic origin with respect to the latter, or that those earthquakes originating from a given centre or focus are generally caused by similar subterranean disturbances.

IX. Duration of the Preliminary Tremor in the Earthquakes of Groups VIII A and VIII B.

§ 14. In the macro-seismic disturbances of near origin, or the earthquakes of Group VIII A, the duration of the total preliminary tremor varied, with a few exceptions, between 3 and 17 sec.; those most frequently occurring being from 6 to 11 sec. The frequency of the different cases was as follows.—

TABLE XXIV.

DURATION OF THE PRELIMINARY TREMOR.
[EARTHQUAKES OF GROUP VIII A.]

Duration of total preliminary tremor.	Number of cases.	Duration of total preliminary tremor.	Number of cases.
sec. 3	1	sec. 13	2
4	2	14	4
5	1	15	2
6	9	16	2
7	5	17	2
8	5	18	1
9	3	19	1
10	4	22	1
11	6	29	1
12	3		

Again, in cases of the local *unfelt* earthquakes, or those of Group VIII B, the duration of the total preliminary tremor varied, with a few exceptions, between $2\frac{4}{10}$ and 25 sec.; the frequencies of the different cases being as follows.—

TABLE XXV.

DURATION OF THE PRELIMINARY TREMOR.
[EARTHQUAKES OF GROUP VIII B.]

Duration of total prel. tremor.	Number of cases.	Duration of total prel. tremor.	Number of cases.
sec. $2\frac{4}{10}$	1	sec. 16	4
5	2	17	1
6	2	18	2
7	1	19	1
8	1	21	2
9	2	22	2
10	2	24	1
11	1	25	2
12	4	28	1
13	1	33	1
14	2	37	1
15	2	58	1

The data contained in the above two tables will be of use in the estimation of the focal depth of the local earthquakes.

X. Annual Distribution of the Earthquakes of Groups VIII A and VIII B.

§ 15. The small local earthquakes, namely, those of Group VIII A and VIII B occurred much more frequently in the summer months than in other parts of the year, as will be seen from the following table.

TABLE XXVI.

ANNUAL DISTRIBUTION OF THE EARTHQUAKES OF GROUPS VIII A AND VIII B.

Month.	Number of earthquakes.			Season.	Number of earthquakes.
	Group VIII A.	Group VIII B.	Sum.		
XII, 1900	3	5	8		
I ,,	2	2	4	Winter.	27
II ,,	8	7	15		
III ,,	7	8	15		
IV ,,	12	3	15	Spring.	40
V ,,	5	5	10		
VI ,,	23	8	31		
VII ,,	29	11	40	Summer.	87
VIII ,,	6	10	16		
IX ,,	5	1	6		
X ,,	9	2	11	Autumn.	37
XI ,,	9	11	20		
Sum	118	73	191	Sum.	191

The annual variation of these small earthquakes, most of which were *unfelt* ones, does not coincide with that of the earthquakes observed in Tōkyō by means of Palmieri's and Gray-Milne's seismographs;* the dffierence probably arises from the difference in the origins of the majority of earthquakes in the different sets of the observations. The discussion of this point must be postponed to some future occasion.

* See the *Publications*, No. 8.

XI. Pulsatory Oscillations.

§ 16. A short note on the *pulsatory oscillations* observed at Hongō in 1898-1899 has been given in the *Publications*, No. 5 (pp. 51-57), according to which the average period of these movements varied between 3.4 and 8.0 sec., that of 3.9 to 4.5 sec. occurring most frequently. A careful examination of the horizontal pendulum diagrams shows, however, that the pulsatory oscillations consist, in most cases, essentially of the vibrations with a period of about 4 sec., more or less mixed up with those of a period of about 8 sec. The vibrations of 4 second period occur very frequently, but cases are not wanting, where the vibrations of the 8 seconds period predominate almost exclusively. Again there are sometimes cases, in which the two kinds of vibrations occur in different parts of one and the same diagram. The following are some of the instances of this nature.

Jan. 24-25, 1900. Till about 2 p.m. on the 24th, the pulsatory oscillations had essentially an average period of 4,4 sec. After 2 p.m., the principal average period was 7,1 sec., the max. 2a being 0,05 mm.

Feb. 17-18, 1900. On the morning of the 18th, the average period was 3,8s; while, on the 17th, it was 8,1 sec.

Feb. 20-21, 1900. Pulsatory oscillations of an average period of 8,1 sec., occurred till about 9 p.m. in the evening of the 20th, while those of an average period of 4,4 sec. occurred throughout after that hour.

Nov. 6-7, 1900. Till about 1 a.m. of the 7th, the motion was uniform and had an average period of 7,5 sec. (max 2a=0,06mm). During the rest of the morning of the same day, the average period was 3,9 sec. (max. 2a=0,06mm.)

The following example relates to a record from the 120-times magnification tromometer and is given for the sake of reference :—

Nov. 25-26, 1900. The diagram from the tromometer indicated, till about 6p.m. of the 25th, the vibrations of an average period of 3.5 sec. (max. 2a=0.008 mm), more or less grouped into movements of a slower period. Thereafter the motion became uniform and had an average period of 6.9 sec. (max. 2a=0.008 mm). On account of the smallness of the amplitude, the diagram from 0-times magnification instruments only indicated the slower vibrations.

§ 17. Table XXVII gives the average period and the maximum range of motion in the 46 cases observed in 1900 at Hitotsubashi. These are not of course exhaustive the measurements having only been made in so far as these movements occurred in the diagrams which contained earthquakes. The average period was each time deduced from 100 or 200 consecutive vibrations.

TABLE XXVII.

LIST OF THE PULSATORY OSCILLATIONS, OBSERVED IN 1900 AT TOKYO. (**Hitotsubashi.**)

1900. Date and hour.		2a, or double amplitude.	Average period.
		mm	s
Jan. 20;	2½ p.m.	0,03	4,6
" 21;	1 a.m.	(Small)	5,1
" " ;	6 p.m.	"	5,0
" " ;	7½ p.m.	"	4,6
" 24;	3½ p.m.	"	4,4
" " ;	5½ p.m.	0,05	7,1
" 30;	9 a.m.	0,04	4,1
" " ;	11 p.m.	(Small)	5,1
Feb. 3;	7 p.m.	0,06	3,8
" 5;	6½ p.m.	0,06	4,9
" 17;	2 p.m.	(Small)	8,1
" 18;	Morning.	0,08	4,2
" " ;	"	(Small)	3,8
" 20;	till 9 p.m.	"	8,1
" " ;	after 9 p.m.	"	4,4
" 24;	Morning.	"	5,0
" 26;	10 p.m.	0,05	3,8
March 1;	6½ a.m.	(Small)	4,4
" 7;	7½ p.m.	0,04	3,4
" 10;	2 a.m.	(Small)	3,5
" 14;	11½ p.m.	"	4,2
" 15;	6 a.m.	0,20	4,6
" " ;	6 p.m.	(Small)	5,5
" 16;	5 a.m.	"	5,2
" 23;	7 a.m.	0,06	4,4
" 28;	7½ p.m.	0,05	4,0
" 29;	2 p.m.	(Small)	3,8
April 1;	9 p.m.	0,11	5,6
" 20;	8 a.m.	(Small)	4,4
" " ;	9½ p.m.	0,14	4,5
" 25;	4 p.m.	0,05	4,0
May 5;	11 p.m.	(Small)	4,3
" 15;	6 a.m.	0,05	3,7
" 30;	1½ p.m.	0,03	3,7
Aug. 25;	11½ p.m.	0,04	5,3
Sept. 18;	11 a.m.	(Small)	5,7 (?)
" 24;	4 a.m.	0,08	4,5
Oct. 8;	3 a.m.	(Small)	3,8
" 10;	1 p.m.	0,04	4,2
" 16;	Noon.	0,03	3,9
Nov. 1;	9¾ a.m.	0,09	3,8
" 7;	till 1 a.m.	0,06	7,5
" " ;	after 1 a.m.	0,06	3,9
" 19-20;		0,06	9,3
Dec. 2;	4-5 a.m.	(Small)	3,9
" 8;	Morning.	"	5,1

From the above table, it will be seen that in 41 out of the 46 cases, the average period varied between 3,4 and 5,7 sec., giving a mean value of 4,4 sec. ($=Q_1$). In the remaining five cases, the average period varied between 7,1 and 9,3 sec., giving a mean value of 8,0 sec. ($=Q_2$). It thus seems probable that the pulsatory oscillations are essentially composed of two series of vibrations, whose periods are respectively about 4 sec. and 8 sec.; large pulsatory movements, which are caused by very deep cyclones having generally the 8 seconds period. Some of the cases, in which the period is between 4 and 8 seconds, are probably produced by the mixing together of the two series of the movements. We may perhaps assume that the 8-seconds period vibration constitutes the fundamental oscillation proper to the Tōkyō plain, the 4-seconds period vibration being one of its harmonics.

§ 18. *On the period of vibration in the preliminary tremors of distant earthquakes.*

The result obtained in the above § seems to offer an explanation of the phenomena of the preliminary tremors of distant earthquakes so far as the period of vibration is concerned. Thus, according to § 5, there are two predominating periods, P_1 and P_2, in the 1st and 2nd preliminary tremors, as follows.

In 1st prel. tremor, ... $P_1=4,6$ sec.; $P_2=8,7$ sec.;
,, 2nd ,, ,, , ... ———— ; $P_2=8,5$,, ;

these being the mean results deduced from the 82 distant earthquakes observed in 1900 at Hitotsubashi. The values of the two predominating periods, P_1 and P_2, found for Hongō, are nearly identical with those for Hitotsubashi, as follows.—

In 1st prel. tremor, ... $P_1=4,6$ sec.; $P_2=8,0$ sec.;
,, 2nd ,, ,, ... ———— ; $P_2=8,1$,, ;

these being the mean results deduced from the observations of 95 distant earthquakes, whose duration was between ¾ hour and several hours.* Taking together the results for Hitotsubashi and Hongō,

* See the *Publications*, No. 5, pp. 37-42.

we see that the principal periods of vibration in the 1st and the 2nd preliminary tremors are

$$P_1 = 4,6 \text{ sec.}, \quad P_2 = 8,3 \text{ sec.},$$

which are practically identical respectively with the two periods of $Q_1 = 4,4$ sec. and $Q_2 = 8,0$ sec. found for the pulsatory oscillations in Tōkyō. As, further, the periods P_1 and P_2 do not depend on the distance of a seismic origin from the observing station, I conclude that the principal vibrations in the preliminary tremors of distant earthquakes and the pulsatory oscillations are identical phenomena; in other words, the period in the preliminary tremors do not depend on the nature of the disturbance at the seismic origin, but are characteristic to the region about Tōkyō. The formation of the vibrations, which constitute the preliminary tremors may be explained as follows:—The disturbance at the commencement of the 1st preliminary tremor, which has a transit velocity of some 14 km per sec., must travel along a layer at some distance below the earth's surface. (See § 43.) These would constitute a progressive source of disturbance and would communicate a sort of stress to the superimcumbent surface layer of the earth's crust in the region about a given station; the latter being, in consequence, thrown into its own proper oscillations, just as the waters of seas are thrown, by great sub-marine earthquakes or by atmospheric disturbances, into destructive waves, whose periods are the same as those of the waves existing at ordinary times and are constant at each given sea-coast place. By way of reference, we may note that the low atmospheric pressure always produces pulsatory oscillations of some intensity, which shows that the earth's crust, or rather a given district such as the plain of Musashi, is very easily thrown into movements.

§ 19. A glance at the diagrams of pulsatory oscillations shows that the motion consists always of alternations of maximum and minimum groups. This is exactly analogous to the phenomena of beats in acoustics. To take an example, in the great pulsatory oscillation storm on Nov. 17-19, 1900, (*the Publications*, No. 5), the mean value of the intervals between the successive maximum displacements was about 1m 12 s. The motion may be regarded as the resultant of two series of simple harmonic movements of nearly equal amplitudes, whose period were 8 and 9 seconds respectively.

XII. The Preliminary Tremors of the Earthquake Motion.

(A) DISTANT EARTHQUAKES.

§ 20. In the *Publications*, No. 5, p.p. 61-66, I have discussed the relation between the durations of the preliminary tremors at a given station and the distance of the latter from the origin of disturbance. I am here going to consider again the same problem, with additional material recently obtained.

The following table contains the list of the observations of 15 large earthquakes of known origin, whose *spherical* distance (x) from Tōkyō varied between 2200 km and 14200 km. Of these earthquakes, which are arranged in order of the duration (y) of the *total* preliminary tremor, ten occurred in 1900-1902, while the other five took place in 1899 and have already been discussed in the *Publications*, No. 5. The relation between x and y is graphically illustrated in Fig. 4.

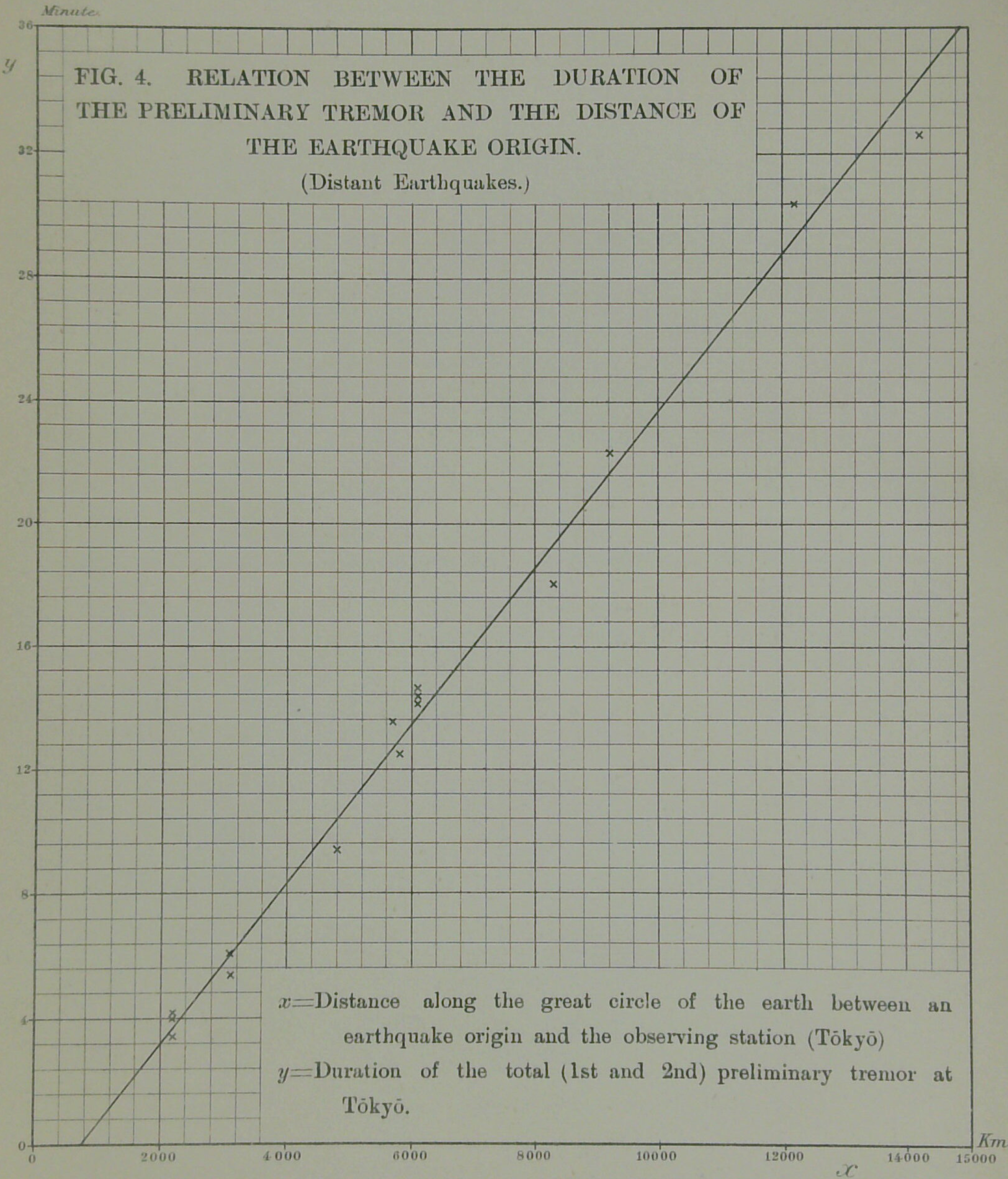


FIG. 4. RELATION BETWEEN THE DURATION OF THE PRELIMINARY TREMOR AND THE DISTANCE OF THE EARTHQUAKE ORIGIN.

(Distant Earthquakes.)

TABLE XXVIII.

THE DURATION OF THE TOTAL PRELIMINARY TREMOR OF DISTANT EARTHQUAKES, OBSERVED IN TOKYO. [$x > 2000$ km.]

No.	Date.	Time of occurrence. (1st. N. J. T.)	y = Total Duration of 1st and 2nd Prel. Tremors.	x = Spherical Distance between earthquake origin and Tokyo.	Origin.
		h m s	m s	km	
1	Nov. 21, 1902	4. 7. 46 p.m.	4. 00	2200	Formosa.
2	June 7, 1901	9. 14. 13 a.m.	3. 29	2200	„
3	Sept. 22, 1902	10. 52. 16 a.m.	4. 4	2200	Guam Island.
4	Dec. 15, 1901	8. 3. 16 a.m.	5. 20	3050	Manila (Mindanao).
5	Aug. 21, 1902	8. 21. 53 a.m.	6. 6	3050	„
6	Sept. 30, 1899	2. 11. 00 a.m.	9. 25	4800	Ceram.
7	Aug. 22, 1902	0. 9. 33 p.m.	13. 30	5700	Kashgar (Turkestan).
8	Jan. 6, 1900	4. 6. 24 a.m.	12. 30	5800	Sumatra.
9	Sept. 4, 1899	9. 31. 59 a.m.	14. 23	6100	Alasca.
10	„ 11, „	3. 14. 16 a.m.	14. 31	6100	„
11	„ „ „	6. 50. 58 a.m.	14. 13	6100	„
12	Feb. 13, 1902	6. 59. 17 p.m.	18. 00	8330	Schemacha.
13	Sept. 20, 1899	11. 24. 27 a.m.	22. 19	9200	Aidin (Smyrna).
14	April 19, 1902	11. 38. 47 a.m.	30. 20	12200	Guatemala.
15	Oct. 29, 1900	6. 31. 52 p.m.	32. 31	14200	Caracas.

Assuming the linear relation $ay+b+x=o$, and determining the values of the constants a and b by the Method of Least Squares from the observations contained in the above table, we obtain the following equation :—

$$x^{\text{km}} = 6{,}54\,y^{\text{sec.}} + 720^{\text{km}}, \qquad (1)$$

where $2000^{\text{km}} < x < 14000^{\text{km}}$

This equation, which slightly differs from those formerly obtained, gives fairly satisfactory results, as will be seen from the following table; the actual and the calculated values of x being on the whole practically identical.

TABLE XXIX.

RELATION BETWEEN THE DURATION OF THE *TOTAL* PRELIMINARY TREMOR AND THE DISTANCE OF THE ORIGIN.

[DISTANT EARTHQUAKES.]

Eqke No.	Total Duration of the 1st and 2nd preliminary tremors.	Actual x.	Calculated x.
	sec.	km.	km.
1	209	2200	2090
2	240	2200	2290
3	244	2200	2320
4	320	3100	2820
5	366	3100	3120
6	565	4800	4420
7	810	5700	6020
8	750	5800	5630
9	863	6100	6370
10	871	6100	6420
11	853	6100	6310
12	1080	8300	7790
13	1339	9200	9480
14	1838	12200	12640
15	1951	14200	13500
	sec.	km.	km.
Mean	**820**	**6090**	**6080**

(B) EARTHQUAKES OF NEAR ORIGIN.

§ 21. Let us next confine our attention to earthquakes of comparatively near origin. The following table contains a list of the 14 earthquakes,* the distances of whose origins from Tōkyō varied

* Of these, five earthquakes took place between Dec. 1898 and 1900, while the remaining nine occurred previous to Aug. 1898 and have already been discussed in the Jour. Sci. Coll., Tōkyō Imp. Univ., Vol. XI.

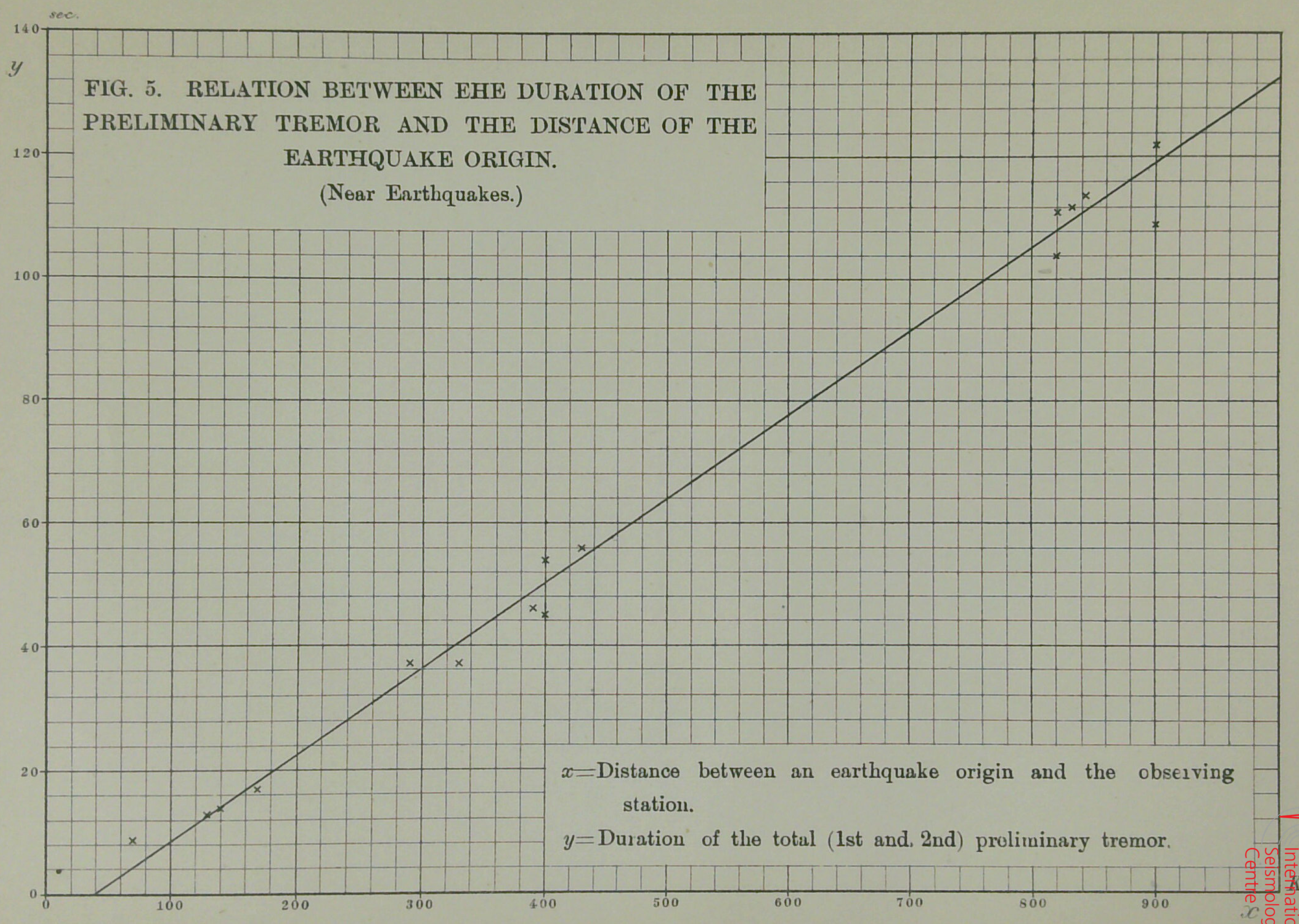


FIG. 5. RELATION BETWEEN EHE DURATION OF THE PRELIMINARY TREMOR AND THE DISTANCE OF THE EARTHQUAKE ORIGIN.
(Near Earthquakes.)
x=Distance between an earthquake origin and the obseiving station.
y=Duration of the total (1st and, 2nd) preliminary tremor.
sec.
y
140
120
100
80
60
40
20
0
100
200
300
400
500
600
700
800
900
Km
x

between 70 km and 900 km. Of the 17 observations on these earthquakes, nine were made by means of Ewing's or Gray-Milne's seismographs, while the rest were made by means of the continuous registering mechanical horizontal pendulum apparatus. The relation between the duration and the distance is illustrated in Fig. 5.

TABLE XXX.

THE DURATION OF THE TOTAL PRELIMINARY TREMOR OF THE EARTHQUAKES. [$x<1000$ km.]

No.	Date.	Time of occurrence in Tokyo (1st N. J. T.)	Duration of preliminary tremor.	Distance between earthquake origin and place of observation.	Place of observation.	Origin.
		h m s	sec.	km.		
1*	Oct. 28, 1891	6. 39. 11 a.m.	37	288	Tōkyō.	Mino, Owari, Echizen.
2*	(Same eqke)	,,	14	140	Osaka.	Do.
3*	March 22, 1894	7. 27. 49 p.m.	109	900	Tōkyō.	Off SE coast of Hokkaido.
4*	Nov. 30, 1894	8. 30. 57 p.m.	9	70	,,	In Tokyo Bay.
5*	Aug. 31, 1896	5. 9. 33 p.m.	56	430	,,	Rikuchu and Ugo.
6*	Jan. 17, 1897	0. 49. 28 a.m.	17	170	,,	Nagano.
7*	Aug. 5, 1897	9. 12. 23 a.m.	45	400	,,	Off the NE coast of Main Island.
8	April 23, 1898	8. 37. 00 a.m.	54	400	,,	Do.
9	May. 26, 1898	2. 59. 57 a.m.	17	170	,,	Echigo.
10	Aug. 12, 1898	9. 35. 34 a.m.	122	900	,,	Fukuoka.
11	Dec. 4, 1898	1. 45. 32 a.m.	112	833	,,	Kyushu.
12	March 7, 1899	9. 55. 29 a.m.	43	390	,,	Off E coase of Kii.
13*	(Same eqke)	,,	13	130	Wakayama.	Do.
14*	(,,)	,,	104	820	Miyako.	Do.
15	March 24, 1899	1. 2. 35 p.m.	111	821	Tōkyo.	Kyushu.
16	Nov. 24, 1899	3. 45. 24 a.m.	114	814	,,	Kyushu.
17	March 22, 1900	0. 56. 7 a.m.	37	330	,,	Echizen.

* Those marked with *asterisks* have been observed in Tōkyō by means of Ewing's or Gray-Milne's seismographs.

Assuming again the linear relation $ay+b+x=o$, and determining the values of the constants a and b by the Method of Least Squares from the observations contained in the above table, we obtain the following equation:—

$$x^{km}=7{,}27y^{sec}+38^{km}. \qquad (2)$$

This equation, which is nearly identical with that formerly obtained, gives fairly satisfactory results, except for a case of $x<100$ km, as will bee seen from the following table.

TABLE XXXI.

RELATION BETWEEN THE DURATION OF THE PRELIMINARY TREMORS AND THE DISTANCE OF THE ORIGIN.

[Near Earthquakes.]

No.	Duration of the total preliminary tremor.	Actual *x*.	Calculated *x*.
	sec.	km	km
4	9	70 ‡	102 ‡
2	14	140	140
6	17	170	162
9	17	170	162
1	37	288	307
17	37	330	307
7	45	400	365
8	54	400	431
5	56	430	445
15	111	821	846
14	104	820	793
11	112	833	852
16	114	844	867
12	46	390	373
13	13	130	133
3	109	900	830
10	122	900	926
Mean.	sec. **63**	km **498**	km **496**

(‡ Excepted in the deduction of the mean values.)

In the above table, the *actual x* is, except in earthquake observation No. 4, the distance between the epicentrum and an observing station, the focal depth being supposed not to be very great. This would produce no considerable error for x greater than 100 or 150 km. Thus, to take, as an example, earthquake observation No. 2, the distance (x) between the observing station and the origin of disturbance would be 149 km, instead of the value of the surface distance of 140 km, if we assume the focal depth to be 50 km. In the case of earthquake observation No. 4, x denotes the radial distance between the seismic origin and the place of observation. Equation (2) is to be understood as being valid for the values of x between about 100 km and 900 km, or for the values of y between some 10 sec. and 2 minutes.

The two equations (1) and (2) give practically identical result for large values of x and y. Thus, for $y=1000$ sec. $=16$m 40s, we obtain :—

from equation (1),............$x=7300$ km,

" " (2),............$x=7300$ " .

Again, for $y=2000$ sec. $=33$m 20s, we find :—

from equation (1),............$x=13800$ km,

" " (2),............$x=14600$ " .

§ 22. Equation (2) is very useful in determining the position of the epicentrum of a submarine earthquake.* As an example, let us take the earthquake of march 7,1899 (Eqke observations Nos. 12, 13 and 14), which caused considerable amount of landslips among the mountains of the provinces of Kii and Yamato, and caused in Ōsaka some damage, such as fracturing of chimneys, etc. The duration of the total preliminary tremor indicated by the Gray-Milne type seismograph at the Meteorological Observatory of Wakayama (province of Kii) was 13½ sec.; while the durations of the same epoch observed by means of continuously recording horizontal pendulum apparatus at Tokyo and Miyako (province of Rikuchu) were respectively 47 and 104 sec. The distances of the seismic origin from these three places are found, by equation (2), to be as follows :—

* See the Jour. Sci. Coll., Tōkyō Imp. Univ., Vol. XI.

Distance from Wakayama, ... 136 km
„ „ Tokyo, ... 380 „
„ „ Miyako, ... 794 „

The circles described about the three places as centres and with the radii respectively equal to the values given above, are found to intersect approximately near a point P off the eastern coast ofthe province of Kii, which denotes the position of the epicentre. (See Fig. 6.)

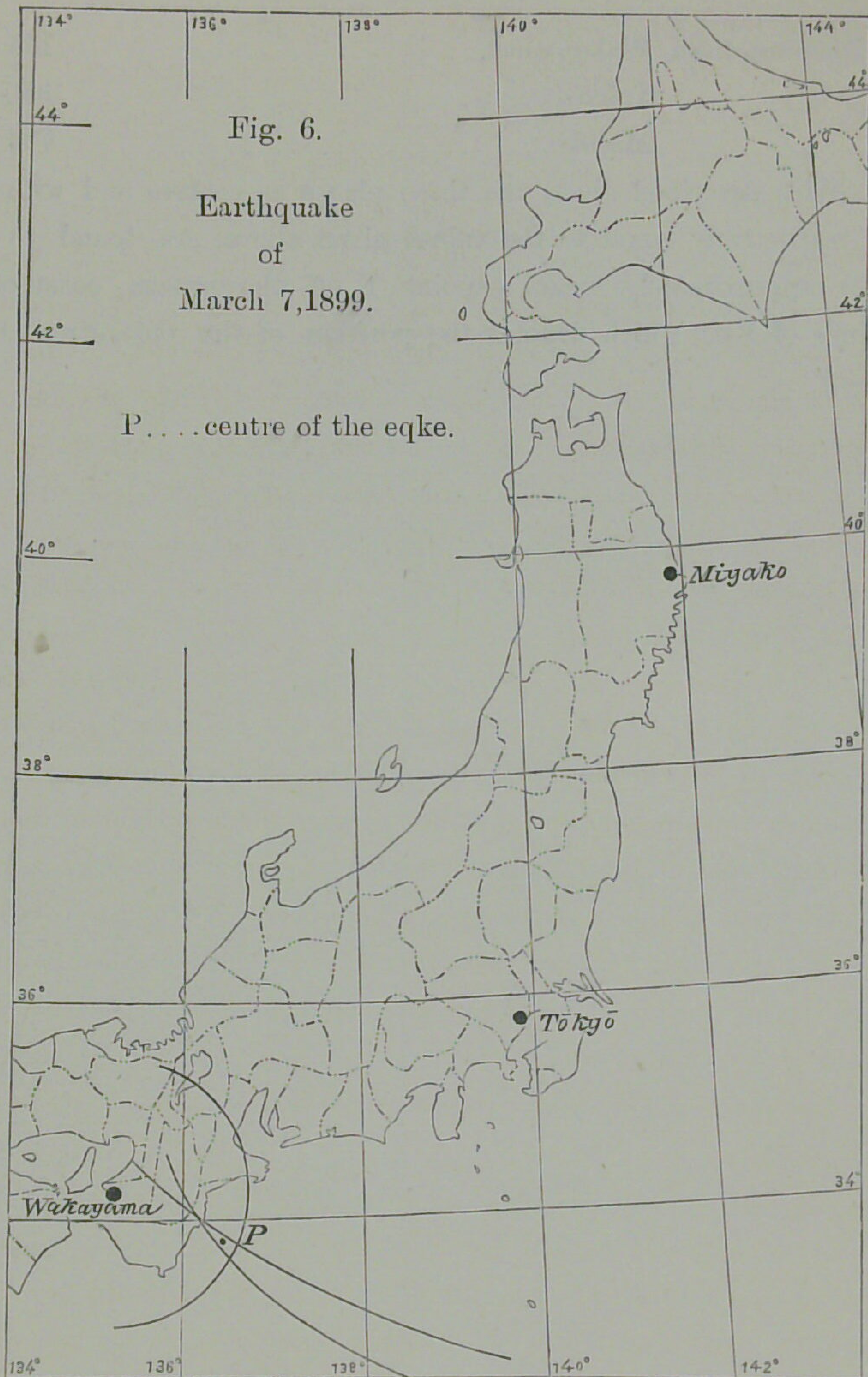


Fig. 6.

Earthquake of March 7,1899.

P....centre of the eqke.

—·—··—·— (Boundary of provinces.)

§ 23. *Explanation of the phenomena of the preliminary tremors.* In a former paper,* I tried to explain the proportionality of the

* Jour. Sci. Coll., Tōkyō Imp. Univ., Vol. XI.

duration of the preliminary tremor with the distance by supposing two (or more) sets of waves, which, originating simultaneously at the centre of disturbance, are propagated with different velocities. This explanation, which assumes the paths of the different sets of waves to be identical, must, however, now be modified somewhat. Thus, the different kinds of waves would not differ much in their transit velocities, if propagated along one and the same path; the difference of the velocity to be modified by the length of the wave, the viscosity of the material of the earth's crust, etc., being anyhow not considerable. (For a discussion on the longitudinal and the transverse components in the earthquake motion, the reader is referred to §§ 47-49.) On the other hand, it is clear from §§ 43 and 55 that the waves in the *1st preliminary tremor*, whose transit velocity is v_1, must be transmitted along a layer at some depth below the surface; while the waves in the *3rd phase* of the *principal portion*, whose transit velocity is v_5, are propagated along the surface. From these considerations, I conclude that the relation of the duration of the preliminary tremors and the distance of earthquake origin is due to the transmission of the disturbances along different routes, and consequently with different velocities; it being only for large values of x, say, greater than 100 km, that the relation between the duration (y) and the distance (x) becomes practically identical as on the supposition of a common path.

§ 24. *On the application of the law of the preliminary tremors to the estimation of the depth of a seismic focus.* If the different sets of waves composing the earthquake motion were propagated along one and the same path, we can at once apply equation (1) or equation (2), properly modified, to the estimation of the focal depth of a local earthquake. But the depth obtained in this way is always found to be much greater than what we might otherwise infer, which is probably due to the transmission of the different kinds of waves along different paths, as stated in the preceding §. The discussion on this important problem must be postponed to a future occasion;

it being necessary, amongst other things, to obtain an accurate knowledge of the transit velocity v_1 for earthquakes of a very near origin.

XIII. Description of the EW component Seismograms of some of the distant great Earthquakes.

§ 25. As illustrations of the characteristics of the motion of distant great earthquakes, I shall here give the analysis of the EW component seismograms, obtained at Hongō (Tōkyō), of the following eleven earthquakes.

TABLE XXXII.

LIST OF GREAT DISTANT EARTHQUAKES.

No.	Date.	Time of occurrence. (1st Normal Japan Time.)	Origin.
		h m s	
a	Sept. 4, 1899	9 31 59 a.m.	Off the SW coast of Alasca.
b	„ 11, „	6 50 58 a.m.	„ „
c	„ 20, „	11 24 27 a.m.	Aidin (Smyrna).
d	Jan. 6, 1900	4 6 24 a.m.	Sumatra.
e	„ 20, „	3 52 39 p.m.	Mexico.
f	Sept. 18, „	7 1 41 a.m.	——
g	Oct. 9, „	9 37 14 p.m.	——
h	„ 29, „	6 29 22 p.m.	Caracas.
i	April 19, 1902	11 38 47 a.m.	Guatemala.
j	Aug. 22, „	0 9 33 p.m.	Kashgar (Turkestan).
k	Sept. 22, „	10 52 16 a.m.	Guam Island.

The description of the first three earthquakes, (a), (b) and (c), are the same as those already given in the *Publications*, No. 6, with some modifications. The five earthquakes in 1900, namely, (d), (e), (f), (g) and (h), correspond respectively to Nos. 2, 13, 259, 277 and 291 in the list of the Hitotsubashi observations (Table I).

§ 26. (a). *Earthquake of Sept. 4, 1899; 9 31 59 a.m.* Total duration = 3h.

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

The *2nd preliminary tremor* lasted 6 m 47 s and began with a motion of 0,46 mm toward W, followed by a well pronounced undulation, whose period was 34 s and which consisted of the two displacements:—(1st) 2,5 mm toward E, (2nd) 4,1 mm toward W. For the rest of this epoch the amplitude did not much vary and was slightly smallar than that of the above introductory wave, the average period being 25,2 sec. The chief vibrations were superposed with smaller ones of an average period of 7,9 s (max 2a=0,6 mm).

The *principal portion* lasted 50 m 33 s. [1st phase]: Duration=2m 35 s. The motion began with two well defined slow undulations of an average period of 34,5 s, the first of which had a max. 2a of 5,6 mm; there being also traces of slow undulations of an average period of 1 m 6 s. [2nd phase]; Duration=3 m 48 s. The motion consisted of seven large undulations, which had an average period of 32,6 s; the second vibration having the max. (abs.) 2a of 15,2 mm. [3rd phase]: Duration=4m 42 s. The motion consisted of 10 vibrations of which the average period was 24 s, and whose first vibration had a max. 2a of 11,1 mm; the last but one vibration being a second maximum, (2a=5,7 mm). [4th phase]: Duration=5 m 28 s. The motion consisted of well defined vibrations of an average period of 14,9 s (max. 2a=5,0 mm); there being five nearly similar maxima, of which the last was the last but one vibration of this epoch. [5th phase]: Duration=7m 20 s. The motion was smaller and consisted of well defined vibrations of an average period of 13,8 s (max. 2a= 3,0 mm); there being five nearly similar maxima, of which the last occurred at the end of this epoch. During the remaining 26 m 40 s of the principal portion, the motion was again much smaller and nearly constant, the average period being 13,4 s (max. 2a=1,7 mm); there being also more or less distinct traces of undulations of an average period of 25 s.

The *end portion.* For the first 21 m 20 s, the vibrations was nearly constant in amplitude (max. 2a=0,7 mm), and had an average period of 20,6 s, superposed by smaller ones of an average period of 9,7 sec. For the next 26 m 0 s, the motion again remained nearly constant (max. 2a=0,55 mm) the principal average period being 10,5 s. Hereafter the motion became very uniform and had an average period of 10,0 s (2a=0,13).

§ 27. (b) *Earthquake of Sept. 11, 1899; 6.50.58 a.m.* Total duration=4 h.

The *1st preliminary tremor,* whose duration was 7 m 43 s, consisted of small vibrations of an average period of 4,3 s, superposed on larger ones of an average period of 9,3 s. The motion was almost perfectly uniform throughout this epoch, the max. 2a being 0,35 mm.

The *2nd preliminary tremor,* whose duration was 6m 30 s, began with a displacement of 2,0 mm toward E, followed by a counter motion of 3,1 mm toward W; the 2nd, 3rd and 5th vibrations were also large, and the two latter had a max. 2a of 3,4 mm, the average period being 25,3 s. During the rest of this epoch, the motion was smaller (max. 2a=1,1 mm) and had an average period of 23,5 s. There were also small quick vibrations (max. 2a=0,25 mm), whose average period was 5,8 s.

The *principal portion.* [1st phase]: Duration=1 m 29 s. The motion consisted of two nearly equal slow undulations with an average period of 44,5 s, whose 2a was 2,3 mm. [2nd phase]: Duration=3 m 21 s. The motion consisted of six large waves, of which the first two had an average period of 37 s, and the following four an average period of 32,5 s, the 5th vibration having the max. 2a of 10,5 mm. [3rd phase]: Duration=8m 48 s. The motion consisted of well defined and nearly equal quicker vibrations, whose average period was 20,7 s; the 4th and the last vibrations having the max. 2a of 3,2 mm. [4th phase]: Duration=8 m 42 s. The motion was again smaller, but nearly constant throughout, and had an average period of 14,9 s; the two maximum movements of 2,1 mm and 1,7 mm having taken place respectively at 1 m 20 s after the commencement, and at the end, of this epoch. [5th phase]: Duration = 7m 43 s. The motion was markedly smaller, but nearly constant throughout, and had an average period of 13,4 s; there being a series of nearly equal maximum movements (2a = 0,9 mm). [6th phase]: During the remaining 8m 9s of the *principal portion*, the motion was again nearly uniform, the principal average period being 14,4 s (max. 2a = 0,8 mm).

The *end portion*. The max. 2a at the commencement of this portion was 0,65 mm, the general average period being 9,8 s.

At 9.19.48 a.m., or 2 h 27 m 50 s after the commencement of the earthquake, there appeared some slow period undulations, whose average period was about 24,7 s, the max. 2a being 0,05 mm. These were the seismic waves, which were propagated from Alasca to Tokyo along the great circle, through the antipode of the latter, and are readiy distinguishable by the length of the period from the quicker vibrations constituting the proper *end portion* of the seismic waves propagated directly, that is to say, along the shortest surface path between the two places.

§ 28. (c) Earthquake of Sept. 20, 1899; 11.24.27 a.m. Total duration = 1 h 15 m.

The *1st preliminary tremor*, whose duration was 10 m 19 s, consisted of small vibrations of an average period of 6,0 s (max. 2a = 0,06 mm); superposed more or less distinctly on traces of slower waves of an average period of 8,7 s.

The *2nd preliminary tremor* lasted 12 m 0 s and consisted of well defined vibrations of an average period of 10,5 s (max. 2a = 0,1 mm), superposed with some minute vibrations.

The *principal partion*. [1st and 2nd phases]: Duration = 12 m 0 s. For the first 4 m 35 s, the motion consisted of small vibrations (max. 2a = 0,1 mm) of an average period of about 13,4 sec., superposed on some traces of slow ill defined undulations. For the next 4 m 50 s, the motion was more active and consisted of seven nearly equal slow undulations of an average period of 41,4 s (max. 2a=0,12 mm), superposed with smaller vibrations of an average period of 10,8 s. During the next 3 m 9 s, the motion consisted of 6½ well defined uniform undulations of an average period of 29,0 s (max. 2a=0,19 mm), superposed by some slight vibrations of an average period of 11,1 s. [3rd phase]: Duration=11 m 45 s. The motion consisted, during the first 7 m 18 s, of vibrations of an average period of 24,3 s (max. 2a=0,45 mm), followed by a single large vibration (abs. max.) of 2a=0,9 mm and of period=16,7 s; the movement during the remaining 4 m 16 s of this epoch having an average period of 18,3 s, superposed by smaller vibrations. [4th phase.] During the remaining 8 m 28 s of the principal portion, the motion was much smaller and nearly constant, the average period being 13,4 s (max. 2a=0,2 mm).

The *end portion.* The motion consisted of small regular vibrations, whose average period was 13,9 s (max. 2a=0,05 mm).

At 1.5.34 p.m., or 1h 41 m 7s after the commencement of the earthquake, there appeared some very slight slow undulations, whose average period was 15,9 s (max. 2a=0,03 mm). These movements, which were indicated for about 5 minutes, were probably the same seismic waves coming along the other path round the earth.

§ 29. (d) Earthquake of Jan. 6, 1900; 4.6.24 a.m. Total duration=2½ h.

The *preliminary tremor* lasted 12 m 32 s. During the first 7 m 24 s, the motion was small and consisted of small regular vibrations of an average period of 7,2 s (max. 2a=0,03 mm). During the remaining 5 m 8 s, the motion was larger and nearly uniform, and consisted of vibrations of an average period of 7,1 s (max. 2a=0,09 mm), superposed on movements of an average period of about 13 s.

The *principal portion.* During the first 5 m 14 s, the motion was ill defined and consisted of slow undulations of an average period of 34,8 s (max. 2a=0,23 mm), superposed by the vibrations of an average period of 7,7 s (max. 2a=0,09 mm). During the next 2 m 37 s, the motion was smaller and had an average period of 24,1 s. For the next 4 m 2 s, the motion became slightly larger (max. 2a=0,13 mm) and had an average period of 20,1 s. Hereafter the motion became regular and quicker in period. Thus, during the next 2 m 56 s, the max. 2a was 0,16 mm and the average period 16,0 s. For the next 5 m 20 s, the motion was most active and had an average period of 13,4 s, the amplitude remaining nearly constant (max. 2a=0,35 mm), superposed by some traces ef quicker vibrations. During the remaining 4m 30 s of the principal portion, the motion was slightly smaller and uniform, the average period being 12,3 s.

The *end portion.* The max. 2a was 0,15 mm, and the average period 10,9 s.

§ 30. (e) *Earthquake of Jan. 29,1900; 3.52.39 p.m.* Total duration=2 h 53 m.

The *1st preliminary tremor* lasted 10 m 40 s. The amplitude remained nearly constant (max. 2a=0,06 mm). During the first 4 m 34 s, the average period was 5,3 s. During the remainder of this epoch, however, the motion consisted of slower vibrations, whose average period was 14,1 s; there being also some traces of small movements.

The *2nd preliminary tremor*, whose duration was 11 m 0 s, consisted of the vibrations of an average period of 7,3 s (max 2a=0,08 mm), superposed on others of an average period of 15,3 s (max. 2a=0,08 mm). The quicker movements predominated during the first half, and the slower ones during the second half, of this epoch.

The *principal portion.* [1st and 2nd phases]: Duration=15 m 54 s. During the first 5m 11 s, the motion was nearly uniform (max. 2a=0,08 mm) and had an average period of 14,1 s. For the next 2 m 33 s, the motion was small. Then the motion became well pronounced and had, during the next 8 m 10 s, an average period of 32,7 s (max. 2a=0,13 mm), the slow undulations being superposed with some traces of quicker period. [3rd phase]: Duration=14 m 13 s. During the first 4 m 59 s, there were 14 regular undulations (max. 2a=0,13 mm), whose average period was 21 s. During the next 5 m 4 s, the motion was smaller and irregular and consisted of vibrations of an average period of 20 s, superposed with smaller waves of an average period of 10,1 s. For the remaining 4 m 15 s of this phase, the average period was 21,8 s, the two first vibrations having the max. 2a of 0,13 mm.

During the remaining 24 m 20 s of the principal portion, the motion consisted of well defined vibrations of an average period of 15,5 s, whose amplitude remained nearly constant, except for the alternation of maximum and minimum groups, whose successive intervals were as follows:—167, 181, 250, 148, 172, 139, 195 sec., the mean value being 179 sec. or about 3 minu'es.

The *end portion* differed, in this case, from the later parts of the principal portion only in the amplitude being slightly smaller, the motion presenting the same alternations of maximum and minimum groups. During the first 12 m 4 s, the average period was 14,5 s (max. 2a=0,1 mm). Then followed four well defined slow undulations of an average period of 20,3 s (max. 2a=0,13 mm), which probably were the same seismic disturbances propagated along the other path round the earth. The average reriods deduced from a series of the successive vibrations were as follows.—

16,2 s (deduced from 15 vibrations),
21,4 („ „ 5 „),
16,0 („ „ 50 „),
16,0 („ „ 50 „).

§ 31. (f) *Earthquake of Sept. 18,1900; 7.1.41 a.m.* Total duration=2½ h.

The *preliminary tremor* lasted together 9 m 4 s. During the first 2 m 58 s, the motion was small (max. 2a=0,06 mm) and consisted of vibrations of an average period of 4,2 s, superposed by slower ones of an average period of 8,6 s. During the next 3 m 4 s, the motion was larger and constant (max. 2a=0,13 mm) and consisted of vibrations of an average period of 8,8 s, superposed by smallar ones of an average period of 3,4 s. During the remaining 3 m 2 s of these epochs, the motion was again larger and consisted principally of the vibrations of an average period of 15,2 s. (max. 2a=0,28 mm), superposed by smaller ones of an average period of 6,6 s (max. 2a=0,13 mm) and those of an average period of 3,8 s.

The *principal portion.* [1st phase]: Duration=1 m 46 s. The motion consisted of 3 nearly equal slow undulations (max. 2a=0,5 mm) whose average period was 35,1 s; these being superposed by the traces of smaller vibrations of the same sort as occurred in the later part of the preliminary tremors. [2nd phase]: Duration=2 m 0 s. The motion consisted of 4½ slow undulations (max. 2a=1,0 mm), whose average period was 26,7 s; these waves being nearly free from superpositions. [3rd phase]: Duration=2m 14 s. The motion consisted of six vibrations of an average period of 22,4 s. The 1st vibration had the max. (abs.) 2a of 2,2 mm; the 2nd, 3rd and 4th vibrations were nearly equal to each other (2a=1,3 mm); the 5th and 6th vibrations were much smaller. [4th phase]: Duration=8 m 34 s. The motion consisted of nearly uniform vibrations of an average period of 10,0 s; there being several nearly equal maxima, of which the greatest (2a=1,0 mm) occurred at the end of this epoch. [5th phase]: Duration=8 m 50 s. The motion consisted of nearly uniform vibrations (max. 2a=0,63 mm), whose average period was 15,7 s, superposed by others of an average period of 8,5 s (max. 2a=0,28 mm). [6th phase]:—During the remaining 9 m 40 s of the principal portion, the motion was smaller and nearly constant, and consisted of the vibrations of an average period of 14,6 s (max. 2a=0,35 mm), superposed by smaller ones of an average period of 8,1 s.

The *end portion.* In the end portion, the motion consisted essentially of the vibrations of an average period of 9,7 s.

At 9.48.41 a.m., or 2 h 47 m after the commencement of the earthquake, there appeared slow undulations of an average period of 19,2 s (max. 2a=0,04 mm), which lasted about 13 m 40 s. These were probably the same earthquake waves propagated round the earth along the other path.

§ 32. (g) *Earthquake of Oct. 9, 1900 ; 9.37.14 p.m.* Total duration = 4 h.

The *1st preliminary tremor* lasted 7 m 22 s, the amplitude being greater during the first 4 m 39 s than during the remaining 2 m 43 s. The motion consisted essentially of slow vibrations of an average period of 14,2 s, whose max. 2a of 0,54 mm occurred at 2 m 42 s from the commencement. These were superposed with quicker vibrations of an average period of 3,7 s (max. 2a = 0,16 mm). During the first 2 m 4 s, there were also very small but perfectly distinct quick vibrations of an average period of 1,5 s (max. 2a = 0,04 mm).

The *2nd preliminary tremor* lasted 5 m 5 s, and began with a displacement of 0,7 mm toward E, followed by a counter motion of 1,43 mm toward W. The 2nd and 3rd vibrations had the ranges of motion of 1,1 mm and 1,78 mm respectively, the average period being 19,6 s. During the remainder of this epoch, the motion was smaller and consisted essentially of undulations of an average period of 24,8 s, superposed throughout with quick vibrations of an average period of 7,8 s (max. 2a = 0,75 mm).

The *principal portion.* [1st and 2nd phases]: Duration = 4 m 5 s. The motion began with a very slow undulation, whose 2a was 1,48 mm and whose period was 44,7 s, superposed with quick vibrations of an average period of 7,5 s. Then there followed the max. (abs.) group, consisting of four undulations, which together lasted 2 m 23 s and had an average period of 35,7 s ; the 2nd vibration having the max. 2a of 4,3 mm. The following two vibrations were smaller (2a = 0,8) mm and had an average period of 28,6 s. [3rd phase] : Duration = 6 m 14 s. The motion consisted of nearly uniform vibrations of an average period of 21,4 s, the max. 2a of 1,5 mm occurring at the commencement and the end of this phase. [4th phase.]: Duration = 6 m 40 s. The motion was slightly smaller than before, and had an average period of 18,2 s ; the max. 2a of 1,43 mm having occurred at the end of this phase. [5th phase.]:—During the remaining 13 m 15 s of the principal portion, the motion remained on the whole constant and consisted of vibrations of an average period of 14,6 s (max. 2a=0,78 mm), mixed up with traces of slow undulations of an average period of 25,0 s.

The *end portion.* During the first 52 m 30 s, the motion consisted of vibrations of an average period of 22,0 s (max. 2a=0,45 mm), superposed with others of an average period of 9,6 s (max. 2a =0,3 mm). Thereafter the motion consisted of regular vibrations of an average period of 8,6 s. Further on the average period was 9.5 s.

At 0. 27. 36 p.m., or 2 h 50 m 22 s after the commencement of the earthquake, there appeared again well defined slow undulations of an average period of 21,4 s, which lasted about 40 m and were probably the same seismic waves propagated along the other side of the earth.

§ 33. (h) *Earthquake of Oct. 29, 1900; 6.29.22 p.m.* Total duration=3¼ h.

The *1st preliminary tremor* lasted 16 m 55 s. During the first 1 m 3 s, the motion was small, the average period being 8 s. During the whole remainder of this epoch, the motion consisted of vibrations of an average period of 14,0 s (max. 2a=0,11 mm), mixed up with quicker vibrations of an average period of 7,4 s (max. 2a=0,11 mm),

The *2nd preliminary tremor* lasted 15 m 36 s. The motion was nearly constant and consisted of vibrations of an average period of 15,6 s (max. 2a=0,15 mm); superposed on slow undulations of an average period of 32,6 s, whose max. 2a of 0,38 mm occurred at 6 m 5 s after the commencement of this epoch. There were also small vibrations of an average period of 7,8 s.

The *principal portion.* [1st phase]: Duration =2 m 49 s. The motion consisted of three nearly equal and extremely slow undulations which together lasted 2 m 49 s and had an average period of

56 s, the max. 2a being 0,25 mm. These waves were superposed with small vibrations of an average period of 10,0 s; the 2nd one being further superposed with very small, but distinct, movements of an average period of 2,9 s. [2nd phase]: Duration = 12 m 13 s. During the first 3 m 47 s, the motion consisted of five nearly equal slow undulations of an average period of 45,4 s, of which the 4th one had the max. 2a of 0,43 mm; there being also small movements of an average period of about 10,3 s. During the next 3 m 31 s, the motion was smaller (max. 2a = 0,3 mm) and ill defined, the average period being about 23,5 s. For the next 2 m 20 s, the motion was most active and consisted of well defined undulations of an average period of 31,2 s, the last but one wave having the max. 2a of 2,1 mm. For the remaining 2 m 35 s of this phase, the motion was small (max. 2a = 0,44 mm) and ill defined, the average period being about 25,8 s. [3rd phase.]: Duration = 13 m 21 s. During the first 2 m 44 s, the motion consisted of well defined vibrations which formed the 2nd maximum group and had an average period of 23,5 s; the 2nd and the last vibrations having the maximum 2a of 1,04 mm. During the next 2 m 49 s, the motion was smaller (max. 2a = 0,24 mm) and had an average period of 21,1 s. Then the motion became slightly larger for the next 2m 54 s (max. 2a = 0,4 mm), the average period being 22 s. Finally, during the remaining 4 m 55 s of the principal portion, the motion consisted of well defined undulations of an average period of 21,0 s, whose max. 2a was 0,86 mm.

The *end portion*. The motion consisted of well defined vibrations (max. 2a = 0,41 mm) whose average periods, deduced from the three successive series of 50 vibrations, were respectively 18,0 s, 17,0 s, and 18,8 s. These movements were divided into maximum and minimum groups, which occurred at fairly regular intervals; the mean interval between the successive maxima being 1m 55 s.

At 8. 8. 47 p.m., or at 1h 39 m 25 s after the commencement of the earthquake, there appeared a well defined maximum group, which consisted of three undulations of an average period of 22,5 s, (max. 2a=0,54 mm). These movements were probably the same seismic disturbances propagated along the other side of the earth. Hereafter the motion consisted of regular vibrations, whose max. 2a and average period deduced from four successive series of 50 vibrations were as follows:—

(1st 50 vibrations)	2a=0,15 mm,	aver. period=16,8 s;
(2nd 50 „)	2a=0,30 mm,	„ „ =17,6 s;
(3rd 50 „)	2a=0,06 mm,	„ „ =17,2 s;
(4th 50 „)	2a=small,	„ „ =16,6 s;

the general mean value of the period being 17,1 s.

§ 34. (i) *Earthquake of April 19, 1902; 11.38.47 a.m.* Total duration=2½ h.

The *1st preliminary tremor* lasted 15 m 40 s. During the first 4 m 35 s, the motion was small and consisted of vibrations of an average period of about 9,2 s. During the next 6 m 32 s, the motion consisted of larger and well defined vibrations of an average period of 6,9 s (max. 2a=0,28 mm), superposed on ill defined traces of slow movements of an average period of about 16,3 s. During the remaining 4 m 22 s, the motion was again much larger (max. 2a =0,65 mm) and had an average period of about 13,1 s; there being some traces of slow undulations of an average period of 40,3 s (max. 2a=0,81 mm),

The *2nd preliminary tremor* lasted 14 m 40 s. During the first 4 m 10 s, the motion was small and consisted of vibrations of an average period of 8,6 s (max. 2a=0,88 mm), superposed on slow undulations of an average period of about 27,8 s. During the remaining 10 m 30 s of this epoch, the vibrations had an average period of 28,3 s; the two max. 2a's of 1,2 mm and 1,0 mm having occurred respectively 4 m 10 s and 8 m 35 s after the commencement of the 2nd preliminary tremor. There were also small vibrations of an average period of about 8,5 s.

The *principal portion.* [1st phase]: Duration=7 m 4 s. The motion began with six well defined and nearly equal undulations (max.

2a=0,7 mm) of an average period of 38,7 s, superposed by traces of small vibrations of an average period of 7,3 s. During the next 3m 12 s, the motion was small (max. 2a=0,25 mm) and the average period was again 38,7 s. [2nd phase]; Duration=4 m 13 s. For the first 2m 13 s, the motion was larger (max. 2a=0,94 mm), the average period being 33,3 s. Then followed four well defined undulations, which together lasted 2 m 0 s and had an average period of 26,7 s; the 2nd and the 4th waves had each a max. 2a of 2,8 mm, while the 1st and the 3rd ones had respectively 2a of 1,4 mm and 2,0 mm. [3rd and subsequent phases.] During the first 3 m 51 s, the motion consisted of vibrations of an average period of 20,1 s; the last and the last but two vibrations having respectively the max. 2a's of 0,63 mm and 0,5 mm. For the next 9 m 43 s, the motion consisted essentially of vibrations of an average period of 34,3 s, of which the max. 2a of 0,63 mm occurred at 7 m 45 s after the commencement of this epoch. During the next 17 m 58 s, the average period was 21,6 s, the max. 2a being 0,44 mm. Again, during the next 9m 22 s, the principal average period was 18,7 s, the max. 2a being 0,31 mm. Then the motion became again somewhat active and there appeared, during the next 13 m 0 s, slow undulations of an average period of 28,4 s (max. 2a=0,31 mm), mixed with movements of an average period of 18,4 s. This group, which occurred at 1. 1. 36 p.m., or 1 h 22 m 49 s after the commencement of the earthquake probably indicated the same seismic disturbance propagated along the other path round the earth. Thereafter motion became gradually small and regular, the average period being 21,3 s.

§ 35. (j) *Earthquake of Aug. 22, 1902; 0.9.33 p.m.* Total duration=4 h.

The *1st preliminary tremor* lasted 6m 44 s, and consisted of nearly uniform vibrations of an average period of 7,1 s (max. 2a=0,22 mm), superposed with slower movements of an average period of 12,3 s and also with quick vibrations of an average period of 3,3 s.

The *2nd preliminary tremor* lasted 6 m 4 6 s and consisted of vibrations of an average period of 9,2 s (max. 2a=2,1 mm), superposed on small movements of other periods.

The *principal portion.* [1st phase]: Duration=1 m 44 s. The motion consisted of two slow undulations of an average period of 52,0 s (max. 2a=0,87 mm). [2nd phase]: Duration=3 m 14 s. The motion consisted of five undulations, of which the first four had an average period of 41,3 s (max. 2a=1,8 mm), and the fifth a period of 29 s (2a=3,0 mm). [3rd phase]: Duration=4 m 48 s. The motion consisted of 16 well defined and nearly equal vibrations, whose average period was 18,0 s; the maximum movements being 5,5 mm (2nd vibration), 5,7 mm (4th and 5th vibrations), and 5,3 mm (13th vibration). [4th phase]: Duration=6 m 0 s. Here, the motion was much quicker, and consisted of 31 nearly equal vibrations, whose average period was 11,6 s; the maximum movements being 3,2 mm (1st vibration), 3,9 mm (7th and 15th vibrations), 4,0 mm (22nd and 23rd vibrations), and 3,3 mm (30th and 31st vibrations). [5th phase]: Duration=9 m 10 s. The motion consisted of 53 nearly equal vibrations, whose average period was 10,4 s (max. 2a=2,5 mm). [6th phase]: Duration=7 m 50 s. Here the motion was much smaller and slower than before, the average period being about 15,7 s (max. 2a=1,25 mm). [7th phase]: Duration=9 m 15 s. During this phase, or the last part of the principal portion, the motion was much smaller (max. 2a=0,62 mm) and the average period was about 16,0 s; there being some traces of movements of an average period of 9,0 s.

The *end portion.* The average period was 13,1 s (measured from the NS component diagram).

At 2.55.18 p.m., or 2 h 45 m 45 s after the commencement of the earthquake, there appeared a maximum group of vibrations, which, in the NS component diagram was well distinct and lasted about 26 m, the average period being 17,6 s (max. 2a=0,07 mm). These movements were evidently the same seismic disturbances propagated along the great circle between Kashgar and Tōkyō on the opposite side of the earth.

Again, at 3. 50. 15 p.m., or 3 h 40 m 42 s after the commencement of the first earthquake, there appeared another group of very slight maximum movements; these were the seismic waves which first reached Tōkyō directly from Turkestan, proceeded further in the same direction, and again reached Tōkyō after passing its antipode, thus travelling once completely round the earth.

§ 36. (k) *Earthquake of Sept. 22, 1902; 10.52.16. a.m.* Total duration = 4 h.

The 1st and 2nd preliminary tremors lasted together 4 m 4 s.

At 1. 52. 39 p.m., or 3 h 0 m 23 s after the commencement of the earthquake, there appeared a group of slight slow movements of an average period of about 19,5 s, which were the same seismic waves propagated along the great circle between the centre of disturbance and Tōkyō through the antipode of the latter.

At 2. 12. 24 p.m., or 19 m 45 s after the commencement of the preceding set of waves, there appeared again a group of very small vibrations, which lasted some 15 m and had an average period of about 19,5 s. These were the seismic waves which were first propagated directly from the origin to Tōkyō and reached the latter a second time after proceeding further in the same direction and passing its antipode.

XIV. Character of Motion of Great Distant Earthquakes.

§ 37. The following discussion of the character of seismic motion is based on the EW component diagrams of the 11 great distant earthquakes, (a), (b), (c)......(j), (k), described in detail in the preceding section.

§ 38. *Amplitude.* The max. 2a in the successive portions of the earthquake motion are given in Table XXXIII, from which we obtain the following mean relative magnitudes of the different maxima :—

Max. 2a in the	1st preliminary tremor			= 100,
,, ,,	2nd	,,	,,	= 560,
,, ,,	1st phase of princ. portion			= 550,
,, ,,	2nd	,,	,,	=1820,
,, ,,	3rd	,,	,,	=1220,
,, ,,	4th	,,	,,	= 840,
,, ,,	5th	,,	,,	= 560,
,, ,,	6th	,,	,,	= 430,
,, ,,	7th	,,	,,	=——.

Thus, the motion in the 1st preliminary tremor is much smaller than in other epochs of the earthquake; while the motion in the 2nd preliminary tremor is practically equal to that in the 1st phase of the principal portion. The amplitude is greatest in the 2nd and the 3rd phases of the latter portion, becoming gradually smaller in the three subsequent phases. (See also § 8.)

According to § 47, the movements in the 3rd phase of the principal portion would be the *longitudinal* motion, while those in the 6th phase would correspond to the transverse motion. The relative values of the maximum 2a in these two phases are respectively 1220 and 430, which are nearly in the ratio of 3 : 1.

TABLE XXXIII.

MAXIMUM RANGES (DOUBLE AMPLITUDES) IN THE SUCCESSIVE STAGES OF MOTION OF THE DISTANT GREAT EARTHQUAKES.

Eqke.	1st prel. tremor.	2nd prel. tremor.	Principal Portion.						
			1st phase.	2nd phase.	3rd phase.	4th phase.	5th phase.	6th phase.	7th phase.
	mm	mm	mm	mm	mm	mm	mm	mm	mm
a	0,25	4,1	5,6	15,2	11,1	5,0	3,0	1,7	—
b	0,35	3,4	2,3	10,5	3,2	2,1	0,9	0,8	—
c	0,06	0,1	0,1	0,10	0,9	0,2	—	—	—
e	0,06	0,08	0,08	0,13	0,13	—	—	—	—
f	0,13	0,28	0,50	1,00	2,20	1,00	0,63	0,35	—
g	0,54	1,78	1,48	4,30	1,50	1,43	0,78	—	—
h	0,11	0,38	0,25	2,10	1,04	—	—	—	—
i	0,65	1,20	0,70	2,80	0,63	0,44	0,31	—	—
j	0,22	2,10	0,87	3,00	5,70	4,00	2,50	1,25	0,62
Mean.	**0,24**	**1,35**	**1,32**	**4,36**	**2,93**	**2,02**	**1,35**	**1,03**	—

§ 39. *Period.* Table XXXIV gives the periods in the successive stages of the earthquake motion, while Table XXXV gives the mean results deduced from the different earthquakes contained in the former. The general average values, $P_1P_2......P_8$ of the various periods are indicated in the last column of Table XXXV, the figures within brackets indicating the numbers of the cases from which the respective values of the periods have been deduced.

From Table XXXV, it will be seen that the 1st phase of the principal portion is characterized by slow movements of P_6, P_7, and $P_{7'}$ types, or those whose average periods are respectively 34,4; 42,9; and 54,0 sec. The 2nd phase is also characterized by slow undulations, the one most frequently occurring being those of P_6 type, whose period is 34,4 sec. In the 3rd phase, the P_5 period (=24,6 sec.) occurs very often; while in each of the three succeding phases the P_3 period (=14,5 sec.) occurs more frequently than the other period. The P_2 period occurs very often in the 1st and the 2nd preliminary tremors and in the end portion.

It is hereby to be noted that slow periods of 30 to 40 seconds occurred sometimes in the 1st and the 2nd preliminary tremors, while quick periods of some 3 or 7 seconds occurred in the 1st phase of the principal portion.

TABLE XXXIV.

PERIODS OF VIBRATION IN THE DIFFERENT PORTIONS OF THE EARTHQUAKES.

Eqke.	1st prel. tremor.	2nd prel. tremor.	Principal portion. 1st. phase.	2nd phase.	3rd phase.	4th phase.	5th phase.	6th phase.	End portion.
	s	s	s	s	s	s	s	s	s
a	3,5 7,9 18,0	7,9 25,2	34,5 66,0	32,6	23,5	14,9	13,8	13,4 25,0	9,7 10,3 20,6
b	4,3 9,3	5,8 24,4	44,5	32,5 37,0	20,7	14,9	13,4	14,4	9,8
c	6,0 8,7	10,5	—	11,8 29,0 41,4	18,3 24,3	13,4	—	—	13,9
d	7,2	7,1 13,0	—	7,7 34,8	20,1 24,1	13,4 16,0	12,3	—	10,9
e	5,3 14,1	7,3 15,3	—	14,1 32,7	10,1 21,0	15,2	15,8	—	15,8
f	4,2 8,6	3,8 7,7 15,2	35,1	26,7	22,4	10,0	8,5 15,7	8,1 14,6	9,7
g	1,5 3,7 14,2	7,8 19,6 24,8	7,5 44,7	28,6 35,7	21,4	18,2	14,6 25,0	—	9,2 22,0
h	7,4 14,0	7,8 15,6 32,6	2,9 10,0 56,0	10,3 25,8 31,2 45,4	21,9	—	—	—	18,0
i	6,9 9,2 14,7 40,3	8,6 28,1	7,3 38,7	26,7 33,3	20,1 34,3	21,6	—	—	18,7
j	3,3 7,1 12,3	9,2 16,0	52,0	41,3	18,0	11,6	10,4	15,7	13,1

TABLE XXXV.

PERIODS OF VIBRATION IN THE DIFFERENT PORTIONS OF THE EARTHQUAKES. *(Continued.)*

(Mean values.)

1st. prel. tremor.	2nd prel. tremor.	Principal Portion.						End portion.	Mean.*
		1st phase.	2nd phase.	3rd phase.	4th phase.	5th phase.	6th phase.		
sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.	sec.
1,5 (1)	—	—	—	—	—	—	—	—	1,5 (1) = —
4,1 (6)	4,8 (2)	2,9(1)	—	—	—	—	—	—	4,1 (9) = P_1
7,8(10)	**8,2** (9)	8,7(2)	9,9(3)	10,1(1)	**11,7**(3)	9,5(2)	8,1(1)	**9,9**(6)	**8,9**(37) = P_2
13,9 (5)	**15,0** (5)	—	14,1(1)	—	**14,9**(5)	**14,3**(6)	**14,5**(4)	**14,3**(3)	**14,5**(29) = P_3
18,0 (1)	19,6 (1)	—	—	**20,4**(9)	19,9(2)	—	—	**19,8**(4)	**20,0**(17) = P_4
—	24,8 (3)	—	—	**24,0**(3)	—	25,0(1)	25,0(1)	—	24,6 (8) = P_5
—	30,4 (2)	—	**27,4**(5)	—	—	—	—	—	28,3 (7) = P_5'
—	—	**36,1**(3)	**33,7**(8)	34,3(1)	—	—	—	—	34,4 (12) = P_6
40,3 (1)	—	44,6(2)	42,7(3)	—	—	—	—	—	42,9 (6) = P_7
—	—	54,0(2)	—	—	—	—	—	—	54,0 (2) = P_7'
—	—	66,0(1)	—	—	—	—	—	—	66,0 (1) = P_8

§ 40. *Duration.* The durations of the different stages of the seismic motion are given in Table XXXVI, from which it will be seen that the successive intervals are *roughly* equal to one another;* the 1st and the 2nd phases of the principal portion being taken together. The durations of the two latter phases are in the ratio of 1 : 1,6.

The relative lengths of the durations of the successive epochs are as follows:—

100	:	95	:	(30+49)		:	91	:	95	:	95	:	88
1st p.t.		2nd p.t.		1st ph.	2nd ph.		3rd ph.		4th ph.		5th ph.		6th ph.

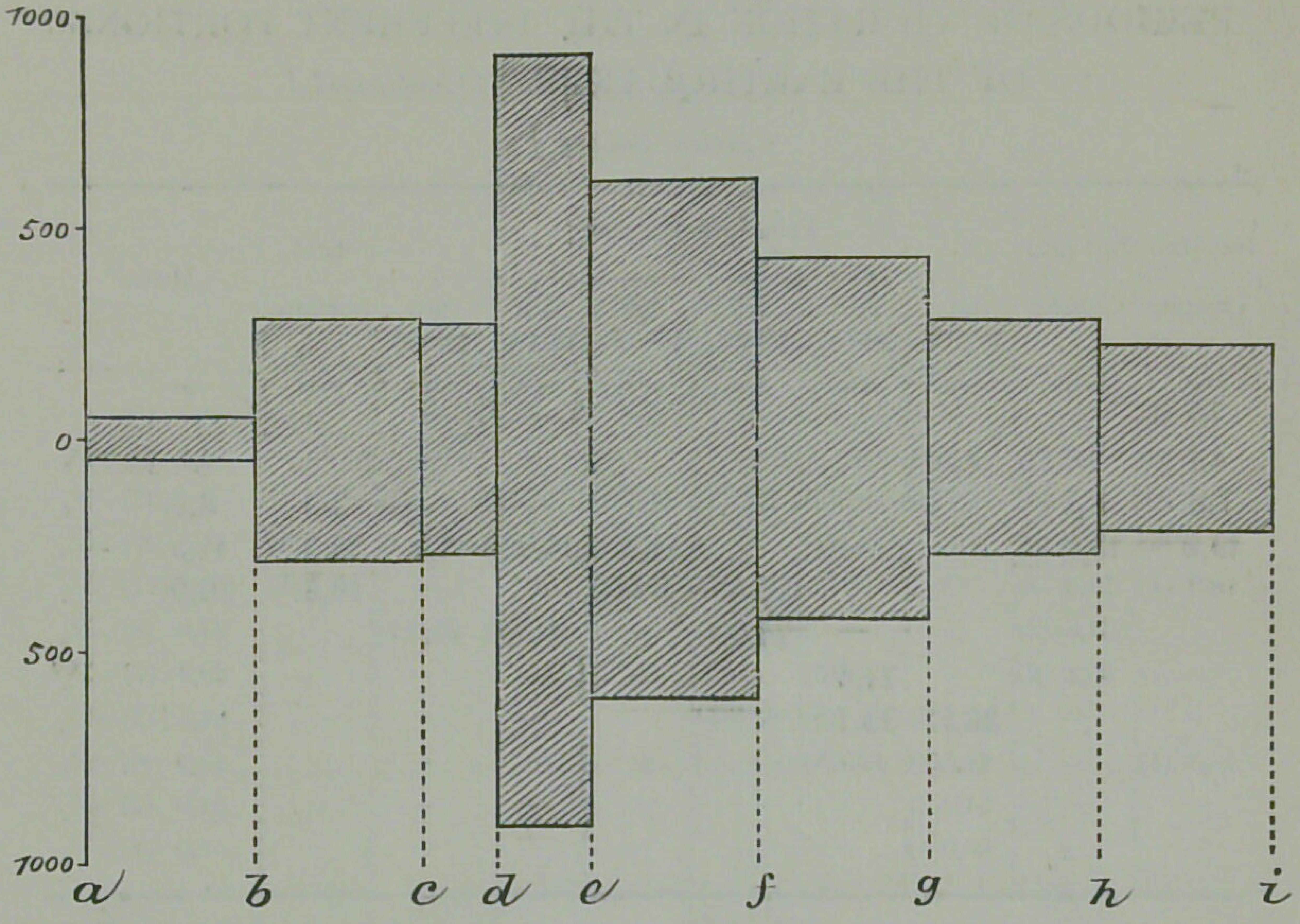
Principal portion

The character of motion of great distant earthquakes is diagramatically illustrated in Fig. 7.

* The notations $P_1 P_2$......are the same are those employed in § 5, with the exception of $P_{5'}$ and $P_{7'}$, which have here been introduced.

Fig. 7.

Diagram showing the relative magnitudes of vibration in the successive stages of motion of distant great earthquakes.



ab....1st Prel. Tremor.	*ef*....3rd phase of Princ. Portion.
bc....2nd ,, ,,	*fg*....4th ,, ,,
cd....1st phase of Princ. Portion.	*gh*....5th ,, ,,
de....2nd ,, ,, ,,	*hi*....6th ,, ,,

(The range of motion in the 1st prel. tremor is taken as 100.)

TABLE XXXVI.

DURATIONS OF THE SUCCESSIVE STAGES OF MOTION OF THE GREAT DISTANT EARTHQUAKES.

Eqke.	1st prel. tremor.	2nd prel. tremor.	Principal Portion.						
			1st phase.	2nd phase.	3rd phase.	4th phase.	5th phase.	6th phase.	7th phase.
	m s	m s	m s	m s	m s	m s	m s	m s	m s
a	7. 36	6. 47	2. 35	3. 48	4. 42	5. 28	7. 20	—	—
b	7. 43	6. 30	1. 29	3. 21	8. 48	8. 42	7. 48	8. 09	—
c	10. 19	12. 00	m (12	s 0)	11. 45	8. 28	—	—	—
e	10. 40	11. 00	(15	54)	14. 13	—	—	—	—
f	4. 32	4. 32	m s 1. 46	m s 2. 00	2. 14	8. 34	8. 50	9. 40	—
g	7. 22	5. 05	m (4	s 05)	6. 14	6. 40	13. 15	—	—
h	16. 55	15. 36	m s 2. 49	m s 12. 13	13. 21	—	—	—	—
i	15. 40	14. 40	7. 04	4. 13	13. 34	17. 58	—	—	—
j	6. 44	6. 46	1. 44	3. 14	4. 48	6. 00	9. 10	7. 50	9. 15
Mean	**9. 43**	**9. 13**	**2. 55** (8	**4. 48** 42)	**8. 50**	**9. 11**	**9. 11**	**8. 33**	—

§ 41. *The transit velocities.* Let us denote by v_1, v_2, $v_3, \ldots v_8$ the transit velocities of the waves of the successive stages of the earthquake motion, namely, the two preliminary tremors and the six different phases of the principal portion. Further, let x denote the distance along the great circle between the earthquake origin and the place of observation; t the time interval required by the waves of the 1st preliminary tremor in traversing the distance x; and y_1 y_2 $y_3 \ldots y_8$ the durations of the successive stages of the motion. We then obtain, by supposing $y_1 = y_2 = y_3 + y_4 = y_5 = y_6 = y_7$, the following relations:—

$$\frac{1}{v_1} = \frac{t}{x};$$

$$\frac{1}{v_2} = \frac{t}{x} + \frac{y_1}{x} = \frac{1}{v_1} + \frac{y_1}{x};$$

$$\frac{1}{v_3}=\frac{t}{x}+\frac{y_1+y_2}{x}\doteqdot\frac{1}{v_1}+\frac{2y_1}{x}\text{ ; etc. ;}$$

where, according to § 54, $v_1=14{,}1\frac{\text{km}}{\text{sec.}}$

Now according to Table XXXVI, the mean value of the total duration of the 1st and the 2nd preliminary tremors is 18 m 56 s, which corresponds, in virtue of equation (1), to $x=8150$ km. Hence, we obtain the following *approximate* results :*—

$$v_1 = 14{,}1\frac{\text{km}}{\text{sec.}},$$
$$v_2 = 7{,}1 \;\;,, \;,$$
$$v_3 = 4{,}7 \;\;,, \;,$$
$$v_4 = (?) \;\;,, \;,$$
$$v_5 = 3{,}5 \;\;,, \;,$$
$$v_6 = 2{,}8 \;\;,, \;,$$
$$v_7 = 2{,}3 \;\;,, \;,$$
$$v_8 = 2{,}0 \;\;,, \;.$$

§ 42. *Lengths of the seismic waves.* The length (λ) of the waves constituting the motion of great distant earthquakes must be generally large. Thus, taking as examples the predominating vibrations in the 1st and 3rd phases of the principal portion, we find, according to §§ 39 and 41,

1st phase of princ. portion, ... $\lambda=4{,}7^{\text{km}}\times 36{,}1^{\text{sec.}}=170^{\text{km}}$;

3rd ,, ,, ,, , ... $\lambda=3{,}3^{\text{km}}\times 20{,}4^{\text{sec.}}=67^{\text{km}}$.

From these calculations it is evident that the slow period earthquake movements are not modified by the nature of the ground.

§ 43. *Paths of the different seismic waves.* In the *Publications*, No. 5, I have stated the view that the disturbances with the transit velocity v_1 probably travels parallel to the earth's surface at some constant depth. The consideration on the prevailing periods in the 1st preliminary tremor (§ 23) seems also to favour this supposition. The layer, along which these high velocity waves are propagated

* These calculations are an extension of similar ones given in the *Publications*, No. 5.

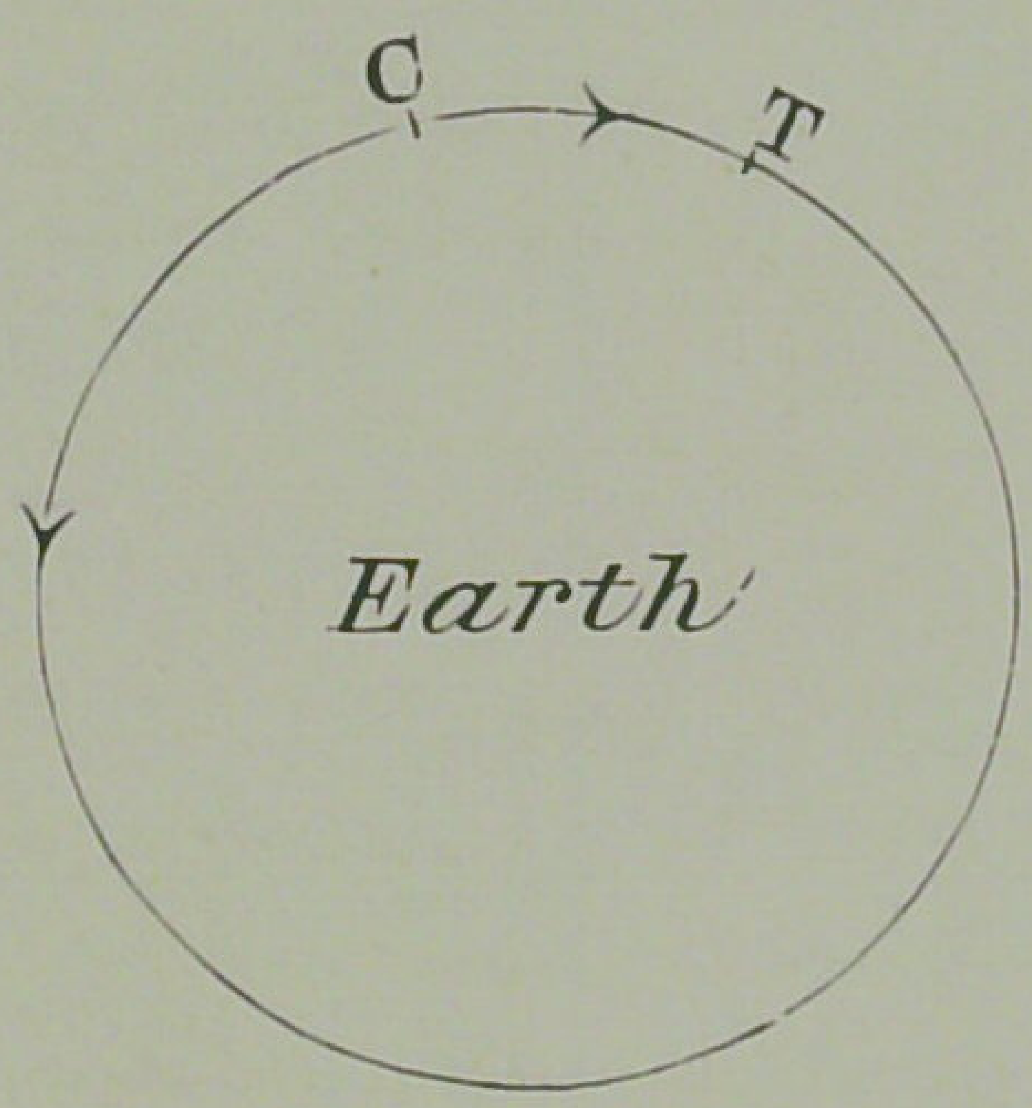
may be, as Professor H. Nagaoka suggests, one of the maximum transit velocity; or may mark the limit beyond which the seismic waves are, on account of certain physical properties of the underlying medium, unable to penetrate. Further, the consideration on the transit velocity of the Caracas earthquake of 1900 (§ 55) seems to indicate that, the waves with the transit velocity v_2 also travel along a layer parallel to the surface of the earth.

That the waves with the transit velocity v_3, or those in the 3rd phase of the principal portion, travel along the surface of the earth is perfectly evident. (See also § 46.)

XV. Propagation of Seismic Waves completely round the Earth.

§ 44. Let T (Fig. 9) be the observing station (Tōkyō), and C the earthquake origin. Then there are three sets of motion, which

Fig. 8.



we may call respectively W_1, W_2, and W_3 waves, as follows:—*firstly*, the W_1 waves are those propagated from C to T along the shortest *surface* path; *secondly*, the W_2 waves are those propagated from C in the opposite direction and reach T after passing through the antipode of C; and *thirdly*, the W_3 waves are the W_1 waves propagated further in the same direction, beyond T, and again reach the latter after once completely travelling round the earth. (Fig. 9, which is the NS component diagram of the Turkestan earthquake of Aug. 22, 1902, recorded at Hongō, Tōkyō, indicated the W_2 and W_3 waves distinctly.)

The identification of the W_3 waves is possible only in a very few number of cases; that of the W_2 waves is, however, more definite, being usually characterized by the fact that their period is much slower than those of the preceding vibrations, which form the *end portion* of the W_1 waves, or the earthquake proper.

Table XXXVII gives the time observations in Tōkyō relating to the three sets of waves, W_1, W_2, and W_3, in cases of the twelve distant earthquakes, of which the first nine, (b), (c), (e), (f), (g), (h), (i), (j) and (k), are the same as those considered in the previous section, while the remaining three, (l), (m) and (n), have been newly added.

TABLE XXXVII.

EARTHQUAKES PROPAGATED ROUND THE EARTH.*

Eq. No.	Date.	Origin.	Commence-ment of the eqke.	3rd phase of the princ. portion.	Commence-ment of W_2 waves.	Commence-ment of W_3 waves.
			h m s	h m s	h m s	h m s
b	Sept. 11,1899.	Alasca.	6. 50. 58 a.m.	7. 10. 01 a.m.	9. 18. 48 a.m.	—
c	„ 20, „	Aidin.	11. 24. 27 a.m.	11. 58. 46 a.m.	1. 05. 34 p.m.	—
e	Jan. 20,1900.	Mexico.	3. 52. 39 p.m.	4. 30. 13 p.m.	5. 20. 50 p.m.	—
f	Sept. 18, „	—	7. 1. 41 a.m.	7. 14. 31 a.m.	9. 48. 41 a.m.	—
g	Oct. 9, „	Alasca.	9. 37. 14 p.m.	9. 53. 46 a.m.	0. 27. 36 p.m.	—
h	„ 29, „	Caracas.	6. 29. 22 p.m.	7. 16. 55 p.m.	8. 08. 47 p.m.	—
i	April 19,1902.	Guatemala.	11. 38. 47 a.m.	0. 20. 24 p.m.	1. 01. 36 p.m.	—
j	Aug. 22, „	Kashgar.	0. 9. 33 p.m.	0. 28. 01 p.m.	2. 55. 18 p.m.	3. 50. 15 p.m.
k	Sept. 22, „	Guam.	10. 52. 16 a.m.	10. 58. 22 a.m.	1. 52. 39 p.m.	2. 12. 24 p.m.
l	June 22,1900.	—	6. 11. 09 a.m.	6. 54. 29 a.m.	—	9. 47. 49 p.m.
m	July 29, „	—	4. 08. 42 p.m.	4. 26. 33 p.m.	—	8. 20. 02 p.m.
n	Aug. 14, „	—	5. 19. 39 a.m.	5. 26. 25 a.m.	8. 00. 28 a.m.	—

§ 45. *Period and Range of motion of the W_1, W_2 and W_3 waves.* Table XXXVIII gives the period and the maximum range of motion of the three sets of waves, namely, W_1, W_2, and W_3 waves, in the twelve earthquakes contained in Table XXXVII; the part of the W_1 waves taken for comparison being the 3rd phase of the principal portion.

1. *Period.* The average period of the W_2 waves is with a few exceptions very uniform, and gives a mean value of 20,4 sec., which is identical with the predominating period in the 3rd phase of the principal portion (see also § 39); the period of the W_3 waves being probably nearly the same as that of the W_2 waves. These facts seem to indicate that the W_2 and W_3 waves are the same vibrations

* The times are given in the 1st Normal Japan Time.

which constitute the 3rd phase of the principal portion of the earthquake proper. That this is probably the case may easily be understood, as the vibrations in the 3rd phase of the principal portion have large amplitude, while their period is tolerably slow, but not so very long as that of the waves in the 1st and the 2nd phases of the same portion.

2. *Amplitude.* The amplitude of the W_2 waves is generally very much smaller than that of the W_1 waves; the motion of the W_3 waves being again much smaller than that of the W_2 waves. This ought of course to be the case, as the intensity of the seismic waves rapidly decreases with an increase of distance from the centre of disturbance.

TABLE XXXVIII.

MAX. 2a AND AVERAGE PERIOD IN THE W_1, W_2 AND W_3 WAVES.

Eqke. No.	3rd phase. of princ. portion.		W_2 waves.		W_3 waves.	
	Max. 2a.	Principal Aver. period.	Max. 2a.	Aver. period.	Max. 2a.	Aver. period.
	mm	sec.	mm	sec.	mm	sec.
b	3,2	20,7	0,05	24,7	—	—
c	0,9	{24,3 / 18,3	0,03	15,9	—	—
e	0,25	21,0	0,13	20,3	—	—
f	2,20	22,4	0,04	19,2	—	—
g	1,50	21,4	Small.	21,4	—	—
h	1,04	21,9	0,54	22,5	—	—
i	0,63	{20,1 / 34,3	0,31	28,4	—	—
j	5,70	18,0	0,07	17,6	Small.	—
k	—	—	Small.	19,5	Small.	19,5
l	0,38	19,3	—	—	0,05	19,2
m	4,3	22,9	—	—	Small.	13,9
n	0,49	8,8	Small.	14,9	—	—
Mean *	mm 1,87	s **20,6**; 8,8; 24,3; 34,3	mm 0,12	**20,4**	—	**19,4**; 13,9

* The period most frequently occurring are prin ed in fat characters.

§ 46. *Velocity of propagation of the W_2 and the W_3 waves.* Table XXXVIII contains the necessary data for the calculation of the transit velocity of the W_2 and W_3 waves; the significations of the different symbols being as follows:—

x = shortest *surface* distance between Tōkyō and the origin of an earthquake;

$\triangle T'$ = time difference between the occurrence of the W_2 waves and that of the 3rd phase of the principal portion;

$\triangle T''$ = time difference between the occurrence of the W_3 waves and that of the 3rd phase of the principal portion.

TABLE XXXIX.

CALCULATION OF THE TRANSIT VELOCITY OF THE W_2 AND THE W_3 WAVES.

Eqke. No.	Total duration of 1st and 2nd prel. tremors	km x	km km $40000-2x$	W_2 waves.		W_3 waves.	
				$\triangle T'$	Transit velocity.	$\triangle T''$	Transit velocity.
	m s			h m s		h m s	
b	14. 13	6100	27800	2. 08. 47	3,6 km/sec.	—	— km/sec.
c	22. 19	9200	21600	1. 06. 48	5,4	—	—
e	21. 40	11000 (?)	18000 (?)	0. 50. 37	5,9 (?)	—	—
f	9. 04	4300*	31400	2. 34. 10	3,4	—	—
g	12. 27	5600*	28800	2. 33. 50	3,1	—	—
h	32. 31	14200	11600	0. 51. 52	3,7	—	—
i	30. 20	12200 (?)	15600 (?)	0. 41. 12	6,3 (?)	-	—
j	13. 30	5700	28600	2. 27. 17	3,2	3. 22. 14	3,3
k	4. 04	2200	35600	2. 54. 17	3,4	3. 14. 02	3,4
l	33. 30	13900*	12200	—	—	2. 53. 20	3,8
m	12. 17	5600*	28800	—	—	3. 53. 29	2,9
n	4. 50	2600*	34800	2. 34. 03	3,8	—	—
Mean.	—	—	—	—	3,7 km/sec.	h m s 3. 20. 43	3,4 km/sec.

* The distances (x) marked with *asterisks* have been calculated by the formula x km = 6,54 y sec. + 720 km.

The transit velocity of the W_2 waves is given by the equation: velocity $=\frac{40000^{km}-2x^{km}}{\triangle T'}$; while the transit velocity of the W_3 waves is given by the equation: velocity $=\frac{40000^{km}}{\triangle T''}$, the circumference of the earth being supposed roughly to be 40000 km. The mean values of the transit velocity is found to be $3,7\frac{km}{sec.}$ for the W_2 waves and $3,4\frac{km}{sec.}$ for the W_3 waves. These results, which are very gross approximations, are to be interpreted as indicating the transit velocity of $3,3\frac{km}{sec.}$. In fact, the Turkestan earthquake (Eqke j), which showed clearly the commencement of the W_2 and W_3 waves, gave the velocities of 3,2 and $3,3\frac{km}{sec,}$ respectively for these two sets of waves.

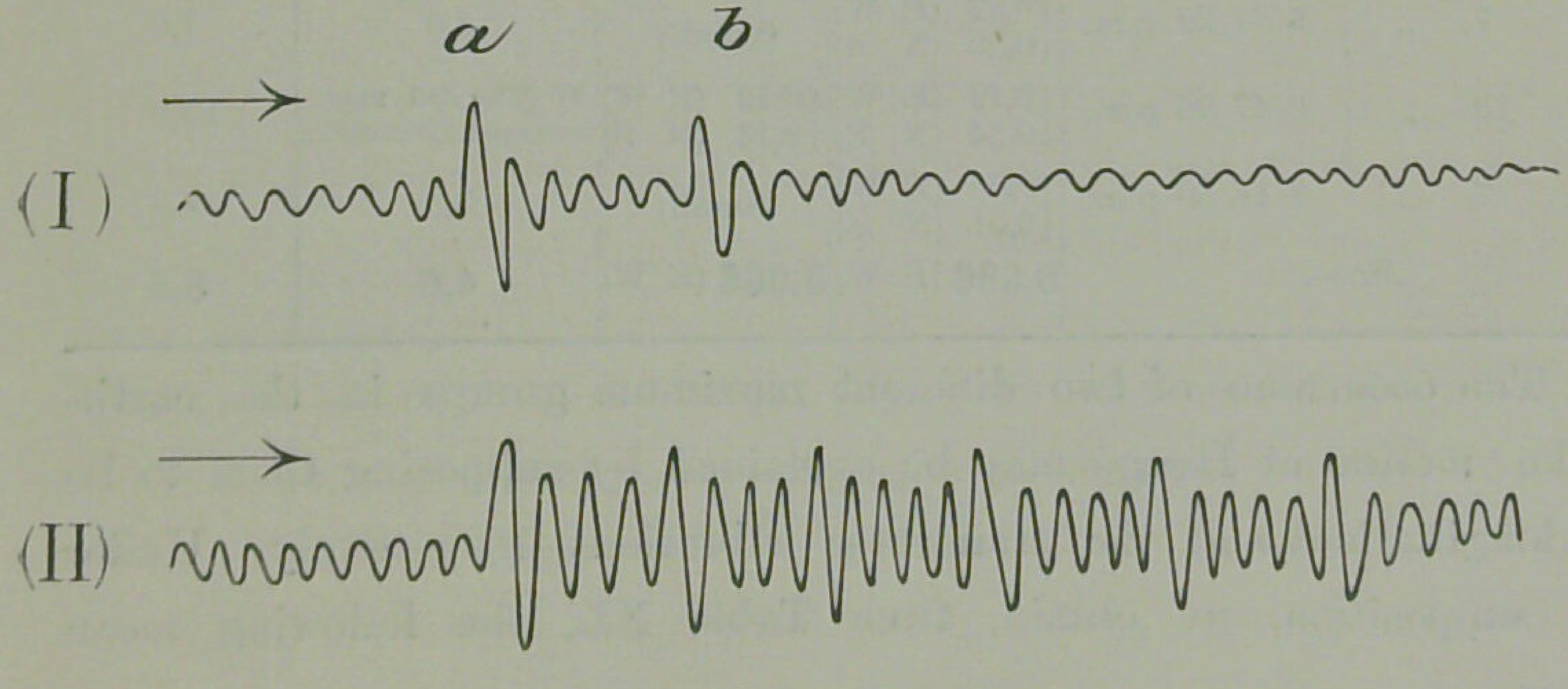
The mean value of $\triangle T''$, which ought to be constant, is 3 h 20 m 46 s, being the time required by the seismic waves, whose velocity is v_5, to travel once completely round the earth.

XVI. Longitudinal and Transverse Vibrations.

§ 47. In the strong motion area of great destructive earthquakes, the directions of the maximum motion at the different places converge, or are symmetrical, to the epifocal region. Again, it is well known that the macro-seismic motion at great distances from the origin consists mainly of horizontal vibrations. These facts seem to show that the most active part of the earthquake motion consists of the longitudinal waves; and we may suppose, therefore, that v_5, which is the transit velocity of the most active portion in the macro-seismic disturbances and also of the 3rd phase of the principal portion in distant earthquakes, characterizes the longitudinal component of the seismic motion. We have, however, no reason to suppose that the transverse component is entirely wanting in the seismic disturbances. Only its amplitude would in most cases be smaller and its transit velocity less than in the longitudinal component. Now, according to the results obtained by Professor H. Nagaoka, who carried on a series of determinations of the elastic moduli of several rock specimens, the ratio of the longitudinal to the transverse velocity would be about 1,6 : 1 for granite, and 1,5 : 1 for andesite. One of the three velocities, v_6, v_7, and v_8, given in § 42, possibly v_8, may be that of the transverse waves; the ratio v_5/v_8 being 1,8 : 1.

§ 48. *Difference of character of the macro-seismic motion at Hitotsubashi and Hongō.* The character of motion of small local macro-seismic disturbances are different at Hongō, where the ground is hard, and at Hitotsubashi, where the ground is very soft. Thus, the horizontal pendulum seismograms obtained at Hongō often presents two (sometimes more) distinct groups of maximum movements (*a* and *b*, Fig. 10, I), separated from each other by a few seconds interval. Such is, however, never the case at Hitotsubashi, the motion there consisting of a series of vibrations, whose amplitude remains, nearly constant during each of the successive epochs, as illustrated in Fig. 10, II. (See also the next Section.)

Fig. 10.



I. Eqke motion at Hongō.
II. „ „ „ Hitotsubashi.

§ 49. *Local shocks observed at Hongō.* The following table has been constructed from the observation of small local earthquakes made at Hongō in 1898-1899. (See the *Publications*, No. 6, p.p. 146-178.)

TABLE XL.

SMALL LOCAL EARTHQUAKES OBSERVED AT HONGŌ.

Date.	Time of occurrence.	2a of 1st Maximum.	2a of 2nd Maximum.	Time interval between 1st and 2nd maxima.	Duration of prel. tremor.
	h m s	mm	mm	sec.	sec.
Oct. 20, 1898	3 15 46 p.m.	0,02 (E W) 0,02 (N S)	(Small)	—	7,7
Dec. 27, ,,	4 43 42 p.m.	0,08 (E W) 0,03 (N S)	0,05 (E W) 0,03 (N S)	2,0	10,0
Jan. 23, 1899	2 55 38 p.m.	0,05 (E W) 0,07 (N S)	0,04 (E W) — —	6,5	?
March 13, ,,	10 51 53 p.m.	0,02 (E W) 0,01 (N S)	0,05 (E W) — —	2,0	5,6
April 2, ,,	11 1 7 p.m.	0,10 (E W) 0,06 (N S)	0,06 (E W) — —	7,8	5,5
,, 20, ,,	5 0 31 p.m.	0,16 (E W) 0,08 (N S)	0,08 (E W) — —	4,5	9,0
May 11, ,,	5 59 12 a.m.	0,05 (E W) 0,01 (N S)	0,07 (E W) — —	4,5	8,3
July 7, ,,	6 32 16 a.m.	0,10 (E W) 0,05 (N S)	0,10 (E W) — —	2,0	4,0
Aug. 1, ,,	9 39 57 a.m.	0,15 (E W) 0,13 (N S)	0,15 (E W) 0,17 (N S)	6,0	7,0
,, 7, ,,	6 11 22 p.m.	0,22 (E W) 0,20 (N S)	(Small)	5,0	7,0
Oct. 10, ,,	6 47 26 p.m.	0,12 (E W) 0,14 (N S)	0,12 (E W) 0,14 (N S)	47 (The 3rd max. occurred 7.3 s after.)	23,0
Nov. 7, ,,	4 48 50 p.m.	0,08 (E W) 0,01 (N S)	(Small)	5,8	6,9
Mean.		**0,096** (E W)	**0,066** (E W)	**4,6**	**8,5**

The occurrence of two different maximum groups in the earthquake motion at Hongō may be explained by supposing them to be the longitudinal and the transverse vibrations respectively. Under this supposition, we obtain, from Table XL, the following mean values :—

Max. 2a of longitudinal motion = 0,096 mm (EW),

,, ,, transverse motion = 0,066 mm (EW).

Thus the longitudinal motion is about $1\frac{1}{2}$ times greater than the transverse. Further, the duration of the preliminary tremor is 8,5 sec. ($=y$), while the time interval between the occurrences of the longitudinal and the transverse vibrations is 4,6 sec. ($=Y$). Now, if v_0 and v' denote the transit velocities of the longitudinal and the transverse vibrations respectively, we have

$$\frac{1}{v'}=\frac{1}{v_0}+\frac{Y}{x},$$

Where x is the distance between the observing station and the seismic origin; the value of v_0 being 3,3 km per sec. Again, in virtue of equation (2), we have, by neglecting the constant term, the following approximate relation:—

$$x=7,27\ y.$$

Hence we obtain the results:—

$$\frac{1}{v'}\doteq\frac{1}{3,3}+\frac{4,6}{7,27\times 8,5},$$

or

$$v'=2,6\frac{\text{km}}{\text{sec.}}.$$

The value of the ratio $\frac{v_0}{v'}$ is about 1,3 : 1.

XVII. The Repetition of Maximum Movements in the Earthquake Motion at Hitotsubashi.

§ 50. In small earthquakes of near origin observed at Hitotsubashi, the principal or most active part of motion consists of quick regular vibrations, with a series of prominent maximum movements of nearly constant amplitude occurring at tolerably regular intervals of about 4 to 6 sec. The following table gives the number (n) of the maxima and the average value (τ) of the successive intervals.*

* The table relates to the EW component alone.

TABLE XLI.

REPETITION OF MAXIMA IN THE EARTHQUAKE MOTION AT HITOTSUBASHI.

n = Number of the maximum displacements in the principal portion;
τ = Average value of the intervals between the succesive maxima.

Group.	Eqke No.	n	τ	Group.	Eqke No.	n	τ
			sec.				sec.
III	45	5	4,8	VIII, A	111	8	3,7
IV	53	7	3,7		172	16	4,0
	00	5	4,1		180	4	5,9
VIII, A	23	8	4,8		204	4	5,4
	57	11	4,9		356	8	3,8
	70	8	6,9	VIII, B	140	9	6,0
	71	—	7,3		179	4	5,9
	77	11	4,2		275	7	4,7
	99	8	5,4	*Mean.*		**8**	**5,0**

As will be seen from the above table, the number n varied between 4 and 16, and had a mean value of about 8; while the interval τ varied between 3,7 and 7,3 sec., and had a mean value of 5,0 sec.

The repetition of maximum movements at regular intervals may be explained by supposing that the earthquake motion at Hitotsubashi is composed of the proper oscillations of the soft surface soil mixed up with the motion of the underlying harder ground. That the proper oscillations always exist to a considerable amount at Hitotsubashi can be inferred from the approximate uniformity of the period of vibration at the latter in different cases; the average period in the principal portion of the earthquakes of Groups VIIIA and VIIIB varying mostly between 0,64 and 0,99 sec. with a mean value of 0,82 sec. (See Table XV.) The range of motion due to the underlying strata, which is probably not much different from the surface ground at Hongō, may be taken as being equal roughly to $\frac{1}{2}$ of that of the other kind of motion; the motion at Hongō being about half of that at Hitotsubashi. (See the *Publications*, No. 11.) Under these suppositions, the state of earthquake shaking at Hitotsubashi may be approximately represented as the resultant of the following two motions:—

$$x_1 = a_1 \sin\frac{2\pi t}{0{,}82\text{sec.}},$$

$$x_2 = -a_2 \sin\frac{2\pi t}{0{,}70\text{sec.}};$$

in which t denotes the time, and x_1 and x_2 denote respectively the movements of the surface soil (period$=$0,82 sec.) and of the lower ground (assumed period$=$0,70 sec.); a_1 being equal to $2a_2$. The successive maxima of the resultant motion occur approximately at an interval of 0,70 sec.$\times 7 \doteqdot$ 0,82 sec.$\times 6 \doteqdot$ 4,9 sec. or very nearly 5 sec., as found actually from the seismograms.

§ 51. *Digression on the motion of a brick wall.* In the *Publications*, No. 12, I have given an account of the measurement of the motion of the eastern outer wall of the Natural History Museum (Hongō), produced by macro-seismic disturbance. The wall, whose height between the ground surface and the coping stone is 53 *shaku*,* was found to be a very weak one; the range of motion at a height of 31 *shaku* being, on average, 3 times as large as that on the ground surface. Further, the period of vibration of the wall was practically constant, the mean value being 0,33 sec. This shows that the wall behaves, in cases of macro-seismic disturbances, like an elastic spring and executes vibrations with its own period, whatever the period and amplitude of the ground motion may be. The vibration was, however, not uniform with regard to the amplitude; there being, in

* 1 *shaku*=0,994 foot.

each case, a series of maximum groups of nearly equal amplitude at fairly regular intervals. The average value of the intervals between the successive maxima was 4,3 seconds, each including some 13 vibrations.

It will thus be observed that the character of motion of the wall in question is much similar to the macro-seismic movements at Hitotsubashi (§ 50). The existence of different maxima in the motion of the wall may be explained by supposing it to be the resultant of the proper oscillation of the wall ($=x_1$), and of the motion of the ground ($=x_2$) of a period of about 0,36 sec., as follows:

$$x_1 = a_1 \sin \frac{2\pi t}{0{,}33 \text{ sec.}},$$

and

$$x_2 = -a_2 \sin \frac{2\pi t}{0{,}36 \text{ sec.}};$$

in which t denotes the time, and a_1 is supposed to be twice as large as a_2. The resultant motion has an average period of 0,33 sec.; while the maximum vibration occurs every 4 sec., which is approximately equal to the value actually found from observation, namely, 4,3 sec. That the above is a probable explanation of the phenomenon in question, which may be called *seismic beats*, may be inferred from the existence of the mean periods of 0,37 and 0,19 sec. in the motion of the ground surface; these being practically identical with, and equal to half of, the period assumed for the motion x_2, namely, 0,36 sec.

XVIII. The Transit Velocities of the Seismic Waves deduced from the observations in Tokyo and Central Europe of recent large Japanese Earthquakes.

§ 52. *Introduction.* This article is to be regarded as the continuation of a similar one given in the *Publications*, No. 5, and contains the results of the calculation of the transit velocities of the seismic waves deduced from the observations in Tōkyō and Central

Europe of nine large earthquakes in recent years, which took place in 1899–1901; all the Tōkyō observations having been made by means of my horizontal pendulum apparatus at the Seismological Institute (Hongō).

Table XLII gives the dates and times of occurrence at Tōkyō of the different earthquakes, as well as the positions and the distances of their origins from the same observing place.

TABLE XLII.

LIST OF LARGE JAPANESE EARTHQUAKES OF RECENT YEARS.

No.	Date.	Time of occurrence in Tokyo.*	Position of the Origin.			Distance between Tōkyō and earthquake origin.
			Locality.	*Lat.* N.	*Long.* E.	
		h m s				km
1	March 7, 1899.	9. 55. 29 a.m.	Off the E coast of the province of Kii.	33° 43′	136° 12′	390
2	May 8, „	0. 28. 54 p.m.	Off the SE coast of Hokkaido.	42°	146°	830
3	June 17, „	10. 9. 35 a.m.	Off the NE coast of the Main Island.	40°	148°	870
4	July 11, „	4. 40. 7 p.m.	Off the SE coast of Hokkaido.	41°	146°	800
5	Nov. 25, „	3. 45. 24 a.m.	Off the E coast of Kyushu.	32° 45′	131° 15′	850
6	Nov. 5, 1900.	4. 41. 42 p.m.	In the vicinity of Jenishima, off the S coast of the Izu peninsula.	33° 43′	139° 5′	230
7	June 24, 1901.	4. 6. 19 p.m.	In the vicinity of Ō-shima, Riu-kiu.	28°	130°	1250
8	Aug. 9, „	6. 24. 56 p.m.	Off the NE coast of the Main Island.	40°	144°	610
9	„ 10, „	3. 35. 47 a.m.	Do.	40°	144°	610

From the above table it will be seen that the distance of the origin of disturbance from Tōkyō varied between 390 and 1250 km. All the nine earthquakes originated off the Pacific coasts of the Japanese Islands. The five earthquakes, Nos. 1,5,6,8, and 9, were

* The time is given in the 1st Normal Japan Time, namely, that of *long.* 135° E.

more or less destructive; while the remaining four were felt *strongly*, but caused no serious damage.

§ 53. *Observations in Central Europe.* The European observations, from which the velocities are calculated, have been taken mostly from the *Bollettino della Societa Sismologica Italiana*; the places of observation being 16 in all, namely, *Trieste, Lemberg, Pola, Quarto-Castello, Pavia, Padova, Ximeniano, Rome, Rocca di papa, Catanzaro, Casamicciola, Catania, Hamburg, Strassburg, Uccle and Shide.*

Table 43, which contains a summary of the European observations, gives, for the different earthquakes, the following quantities.

t_1 = time of commencement of 1st preliminary tremor;

t_2 = ,, ,, 2nd ,, ,,

t_3 = ,, ,, 1st phase of princ. portion;

t_5 = ,, ,, 3rd ,, ,,

x, the spherical distance, or that measured along the great circle of the earth between the origin, (0), of disturbance and a given observing station, (A), has been calculated according to the formula

$$\cos OA = \sin \varphi \sin \varphi_0 + \cos \varphi \cos \varphi_0 \cos (\lambda - \lambda_0),$$

where φ_0 and λ_0 are the latitude and longitude of the origin (0), and λ the φ the corresponding quantities for the observing station (A).

The different time moments t_1, t_2, t_3, and t_5 have been carefully judged from the description of the seismograms at the different stations. Table XLIII also gives, for each earthquake, the mean values of t_1, t_2, t_3, and t_5, as well as those of the x's of the stations whose observations have been utilized in deducing the latter.

TABLE XLIII.

OBSERVATIONS OF THE EARTHQUAKES AT THE DIFFERENT EUROPEAN STATIONS.*

Eq. No.	Place.	t_1	t_2	t_3	t_5	x, or surface distance between earthq. origin and observing stations.
		h m s	h m s	h m s	h m s	km
1	Trieste	2. 06.' 54	—	—	2. 42. 54	9460
	Pavia	—	2. 16. 55	—	—	9760
	Padova	2. 07. 00	—	—	—	9800
	Catania	—	2. 18. 14	—	—	10020
	Mean.	**2. 06. 57** x=9630km	**2. 17. 35** x=9890km	—	**2. 42. 54** x=9460km	km **9760**
2	Trieste.	4. 39. 43	4. 50. 12	—	—	9160
	Quarto-Castello	4. 39. 15	—	—	—	9430
	Padova	4. 39. 00	—	—	—	9490
	Roma	4. 39. 40	4. 50. 50	—	—	9560
	Catanzaro	4. 39. 45	—	—	—	9640
	Casamicciola	4. 39. 47	—	—	—	9600
	Catania	4. 40. 20	4. 50. 41	—	—	9850
	Mean	**4. 39. 38** x=9533km	**4. 50. 34** x=9523km	—	—	**9533**
3	Trieste	2. 18. 48	—	—	—	9420
	Padova	2. 17. 00	—	—	—	9520
	Quarto-Castello	2. 17. 25	2. 26. 30	—	—	9710
	Rocca di papa	2. 20. 10	—	—	—	9830
	Roma	2. 18. 00	—	—	—	9840
	Catanzaro	2. 17. 50	—	—	—	9920
	Catania	—	2. 27. 22	—	—	10150
	Mean.	**2. 18. 12** x=9707km	**2. 26. 56** x=9930km	—	—	**9770**
4	Trieste	8. 47. 07	8. 59. 33	—	—	9250
	Roma	—	8. 58. 40	—	—	9670
	Padova	8. 49. 00	—	—	—	9420
	Casamicciola	8. 49. 11	—	—	—	9690
	Rocca di papa	—	8. 58. 25	—	—	9680
	Catania	8. 50. 36	8. 58. 38	—	—	9930
	Mean.	**8. 49. 00** x=9573km	**8. 58. 50** x=9433km	—	—	**9607**

* The times are given in Central Europe Mean Time.

TABLE XLIII.

(Continued.)

Eq. No.	Place.	t_1	t_2	t_3	t_5	x, or surface distance between earthq. origin and observing station.
		h m s	h m s	h m s	h m s	km
5	Quarto-Castello	19. 54. 37	—	—	—	9510
	Roma	19. 56. 00	20. 07. 30	—	—	9610
	Casamicciola	19. 55. 19	20. 07. 00	—	—	9610
	Catania	19. 55. 36	20. 06. 19	—	—	9770
	Mean	**19. 55. 23** x=9625km	20. 06. 45 x=9663km	—	—	km **9625**
6	Hamburg	—	—	—	9. 39. 44	9140
	Trieste	—	—	—	9. 42. 42	9610
	Strassburg	—	—	—	9. 39. 00	9670
	Shide	—	—	—	9. 40. 18	9830
	Mean	—	—	—	**9. 40. 26** x=9563km	km **9563**
7	Hamburg	8. 16. 19	—	—	8. 50. 05	9240
	Strassburg	8. 16. 40	—	—	—	9240
	Mean	**8. 16. 30** x=9240km	—	—	**8. 50. 05** x=9240km	km **9240**
8	Lemberg	10. 35. 40	—	—	—	8430
	Hamburg	10. 35. 55	—	—	—	8700
	Uccle	10. 36. 11	—	—	—	9170
	Strassburg	10. 36. 07	10. 46. 30	—	11. 07. 00	9260
	Ximeniano	10. 36. 18	10. 46. 52	10. 53. 42	11. 11. 34	9550
	Mean	**10. 36. 02** x=9022km	**10. 46. 41** x=9405km	**10. 53. 42** x=9550km	**11. 09. 17** x=9405km	km **9022**
9	Hamburg	19. 47. 07	—	—	—	8700
	Uccle	19. 46. 23	—	—	—	9170
	Strassburg	19. 46. 40	19. 57. 00	—	20. 30. 00	9260
	Pola	19. 46. 36	—	—	—	9430
	Ximeniano	19. 46. 18	19. 57. 13	20. 12 00	20. 20. 48	9550
	Mean	**19. 46. 39** x=9222km	**19. 57. 07** x=9405km	**20. 12. 00** x=9405km	**20. 25. 24** x=9405km	km **9222**

§ 54. *Calculation of the transit velocities.* I have calculated four different transit velocities, namely, those of the 1st and 2nd preliminary tremors, and of the 1st and 3rd phases of the principal portion; these velocities being denoted respectively by the symbols v_1, v_2, v_3, and v_5. Each velocity has been calculated by the following formula :—

$$v_n = \frac{\overline{x_n} - X_n}{\overline{t_n} - T_n},$$

where X_n and $\overline{x_n}$ are respectively the distance of the earthquake origin from Tokyo and the mean of the distances of the same from the European stations; and T_n and $\overline{t_n}$ are respectively the time of occurrence of a particular epoch of the earthquake motion at Tokyo and the mean of the same at the different European stations. $\overline{t_n}$ may be any one of the four quantities, $\overline{t_1}$, $\overline{t_2}$, $\overline{t_3}$ and $\overline{t_5}$. Similarly T_n may be any one of the four quantities, T_1, T_2, T_3, and T_5; these latter being respectively the time of commencement at Tokyo of the 1st and the 2nd preliminary tremors, and of the 1st and the 3rd phases of the principal portion. As the seismic origins were each not far from Tokyo, the seismograms at the latter place enabled me to determine only the time moments T_1 and T_3 (except in the case of eqke No. 6, where T_2 was also definitely shown). From § 40, however, we may, without a sensible error, put

$$T_2 = \frac{T_1 + T_3}{2},$$

and

$$T_5 = T_3 + \left(\frac{T_3 - T_1}{2}\right).$$

The necessary data for the calculation of the four transit velocities are contained in Tables XLIV and XLV, which give respectively a summary of the time observations of the earthquakes, and the values of the time and the distance differences between Central Europe and Tōkyō.

TABLE XLIV.

SUMMARY OF THE OBSERVATIONS AT THE DIFFERENT STATIONS.*

Eq. No.	Observation in Tokyo			Observation in Europe.			
	T_1	T_2	T_3	$\overline{t}_1$	$\overline{t}_2$	$\overline{t}_3$	$\overline{t}_5$
	h m s	h m s	h m s	h m s	h m s	h m s	h m s
1	1. 55. 29	—	1. 56. 15	2. 06. 57	2. 17. 35	—	2. 42. 54
2	4. 28. 54	—	4. 30. 37	4. 39. 38	4 50. 34	—	—
3	2. 9. 35	—	2. 12. 07	2. 18. 12	2. 26. 56	—	—
4	8. 40. 7	—	8. 42. 30	8. 49. 00	8. 58. 50	—	—
5	19. 45. 24	—	19. 47. 18	19. 55. 23	20. 06. 45	—	—
6	8. 41. 42	8. 41. 59	8. 42. 09	—	—	—	9. 40. 26 (?)
7	8. 06. 19	—	8. 08. 29	8. 16. 30	—	—	8. 50. 05
8	10. 24. 56	—	10. 26. 06	10. 36. 02	10. 46. 41	10. 53. 42	11. 09. 17
9	19. 35. 47	—	19. 36. 57	19. 46. 39	19. 57. 07	20. 12. 00	20. 25. 24

* The times of occurrence are all given in the Central Europe Mean Time, or that of long. 15° E.

TABLE XLV.

SUMMARY OF THE RESULTS OF THE OBSERVATIONS AT THE DIFFERENT STATIONS.

Eq. No.	Commencement of the 1st prel. tremor.		Commencement of the 2nd prel. tremor.		Commencement of the 1st phase of princ. portion.		Commencement of the 3rd phase of princ. portion.	
	$\overline{t}_1-T_1$	Distance difference.	$\overline{t}_2-T_2$	Distance difference.	$\overline{t}_3-T_3$	Distance difference.	$\overline{t}_5-T_5$	Distance difference.
	m s	km	m s	km	m s	km	m s	km
1	11. 23	9240	21. 53	9500	—	—	46. 16	9070
2	10. 44	8653	20. 48	8643	—	—	—	—
3	8. 37	8837	16. 04	9060	—	—	—	—
4	8. 53	8773	17. 31	8633	—	—	—	—
5	9. 59	8775	20. 24	8813	—	—	—	—
6	—	—	—	—	—	—	* 58. 03 (?)	9333
7	10. 11	7990	—	—	—	—	40. 31	7990
8	11. 06	8412	21. 10	8795	27. 36	8940	42. 06	8795
9	10. 52	8612	20. 45	8795	35. 03	8795	47. 22	8795
Mean.	m s **10. 13**	km 8662	m s **19. 48**	km **8891**	m s **31. 20**	**8868**	m s **44. 04**	km **8663**
Transit velocity.	$v_1 = 14.1 \frac{km}{sec.}$		$v_2 = 7.5 \frac{km}{sec.}$		$v_3 = 4.7 \frac{km}{sec.}$		$v_5 = 3.3 \frac{km}{sec.}$	

* Omitted in the calculation of the mean values.

According to Table XLV, the final results are as follows:—

$$v_1 = 14{,}1\,\frac{\text{km}}{\text{sec}};$$

$$v_2 = 7{,}5 \;\;,, \;;$$

$$v_3 = 4{,}7 \;\;,, \;;$$

$$v_5 = 3{,}3 \;\;,, \;.$$

The three velocities, v_1, v_2, and v_5, have already been treated of in the *Publications*, No. 5, the values there obtained being nearly similar to those here obtained. The results of the present investigation are to be considered as of a greater accuracy than those just referred to, as the older calculations were based upon the observations at Tōkyō, most of which were made by the ordinary Ewing or Gray-Milne type seismographs.

The four velocities, v_1, v_2, v_3, and v_5, are approximately in the ratios of

$$4 : 2 : 1\tfrac{1}{2} : 1.$$

XIX. The Transit Velocities of the Caracas Earthquake of Oct. 29, 1900, deduced from the observations in Tokyo and Central Europe.

§ 55. The time observations of the great Caracas earthquake of Oct. 29,1900, in Tōkyō and at the different seismological stations in Central Europe are given in the following table; the symbols, t_1, t_2, t_3, and t_5, all expressed in the Central Europe Mean Time, having the same signification as before. The distances (x), measured along the great circle between each station and the earthquake origin, having been calculated on the supposition that the latter was situated in the vicinity of the city of Caracas, say, at *lat.* 10° 30′ N and *long.* 66° 54′ W.

TABLE XLVI.

OBSERVATION OF THE CARACAS EARTHQUAKE OF OCT. 29, 1900.

Place.	t_1	t_2	t_3	t_5	x = Surface Distance between eqke origin and observing station.
	h m s	h m s	h m s	h m s	km
Ischia.	10. 22. 25	—	—	10. 49. 34	8470
Pola.	10. 22. 32	—	—	—	8450
Rocca di papa.	10. 22. 21	10. 32. 00	—	10. 49. 18	8370
Rome.	10. 22. 31	10. 33. 40	—	—	8350
Padova.	10. 22. 00	—	—	—	8300
Quarto-Castello.	10. 21. 37	10. 31. 56	—	10. 46. 40	8250
Hamburg.	10. 22. 19	10. 32. 00	—	—	8200
Pavia.	10. 21. 55	—	—	—	8090
Strassburg.	10. 21. 50	10. 30. 20	—	10. 47. 40	8000
Mean.	**10. 22. 10** km (x=**8275**)	**10. 32. 00** km (x=**8234**)	—	**10. 48. 18** km (x=**8272**)	km **8275**
*Tokyo.**	**10. 29. 22**	**10. 46. 17**	**11. 01. 53**	**11. 16. 56**	**14160**

The three transit velocities, v_1, v_2, and v_5, may be deduced by comparing the observation at Tōkyō with the means of those in Central Europe, as follows:—

$$v_1 = \frac{14160^{km} - 8275^{km}}{10^h 29^m 22^s - 10^h 22^m 10^s} = \frac{5880^{km}}{7^m 12^s} = 13{,}6 \frac{km}{sec.};$$

$$v_2 = \frac{14160^{km} - 8234^{km}}{10^h 46^m 01^s - 10^h 32^m 00^s} = \frac{5930^{km}}{13^m 46^s} = 7{,}2 \text{ ,, };$$

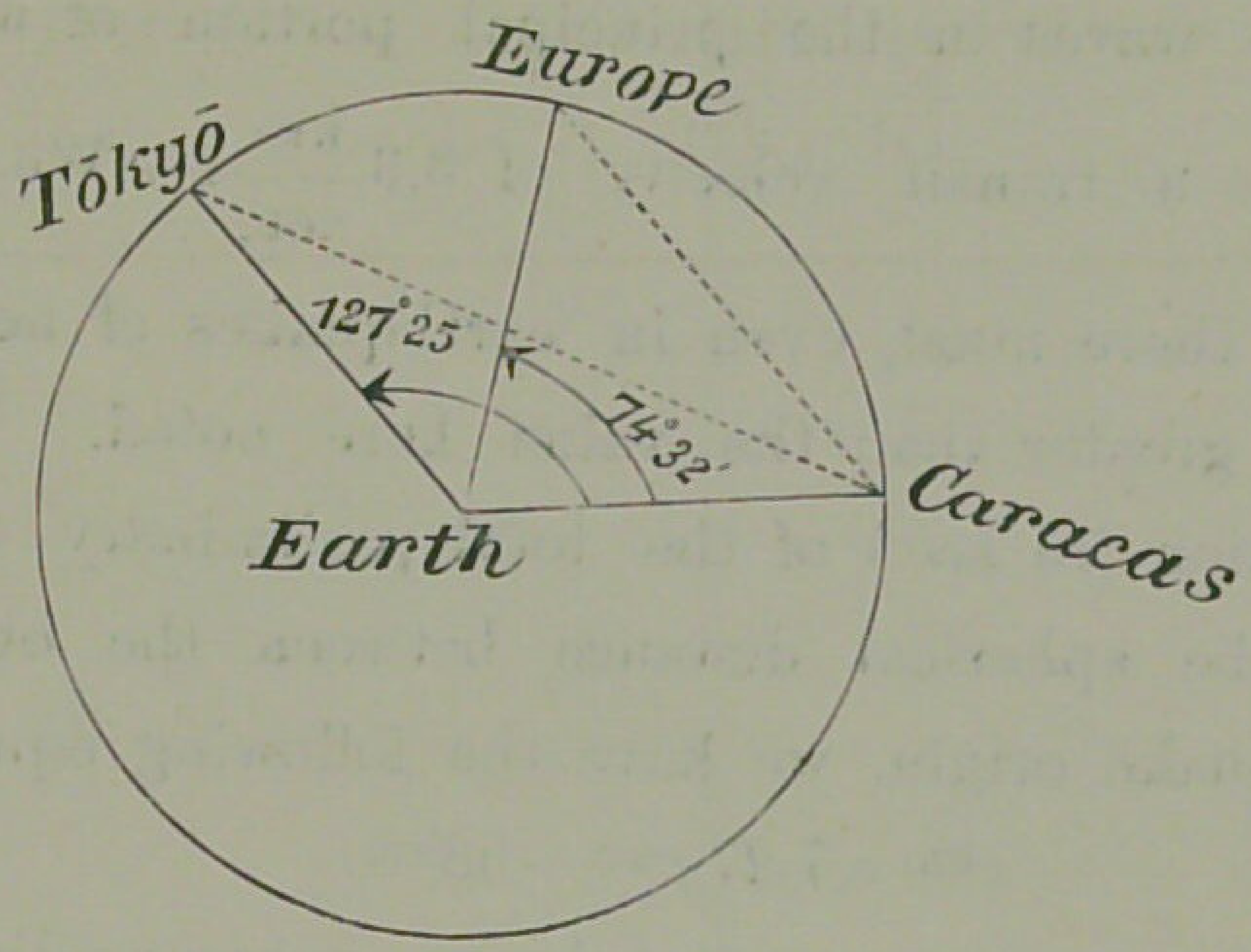
$$v_5 = \frac{14160^{km} - 8270^{km}}{11^h 16^m 56^s - 10^h 48^s 18^s} = \frac{5890^{km}}{28^m 37^s} = 3{,}4 \text{ ,, }.$$

These values of the different velocities are practically identical with those deduced from the observations of the Japanese earthquakes in Tōkyō and Europe (§ 54); the slight differences arising probably

* The time of commencement at Tōkyō formerly given (the *Publications*, No. 5) was slightly erroneous.

from the inaccuracy in the assumed position of the origin of disturbance.

Fig. 11.



Now the angular distance between Caracas and Tōkyō is 127° 25', while that between Caracas and the mean position of the nine seismological stations in Central Europe is 74° 32'. The lengths of the chords subtaining these two arcs are respectively 11420 and 5880 km; so that the velocity v_1, if measured along chord, would come out to be

$$\frac{11420^{km} - 5880^{km}}{10^h29^m22^s - 10^h22^m10^s} = \frac{3710^{km}}{7^m12^s} = 8,6\frac{km}{sec.}.$$

Similarly the velocities v_2 and v_3 would come out to be respectively 4,5 and 2,2 km per sec. These values do not agree at all with the velocities found from the observations of the Japanese earthquakes in Europe. From facts like these, we must infer that the waves with the velocities, v_1, v_2, and v_3, travel parallel or along the earth's surface, and not along the chords, a view which I have stated a few years ago on the ground of the proportionality of the durations of the preliminary tremors to the distance between an earthquake origin and an observing station.*

* See the *Publications*, No. 5, p.p. 69–70.

XX. Note on the Transit Velocity of the Seismic Motion originating at a near distance.

§ 56. The waves in the principal portion of a macro-seismic disturbance has a transit velocity of $3{,}3\frac{\text{km}}{\text{sec.}}$. We can, however, easily see that there must, even in earthquakes of near origin, exist also a velocity greater than the value here noted. Thus, denoting by y the duration (in sec.) of the total preliminary tremor, and by x, as before, the spherical distance between the observing station and the earthquake origin, we have the following equation

$$x^{\text{km}} = 7.27\, y^{\text{sec.}} + 38^{\text{km}}.$$

Hence, if V_1 denote the transit velocity corresponding to the commencement of the earthquake, we have

$$\frac{1}{V_1} = \frac{1}{3{,}3} - \frac{y}{x} = \frac{1}{3{,}3} - \frac{1}{7{,}27} + \frac{38}{7{,}27\,x}.$$

As examples, let us put $x=100$, and $x=\infty$; we then obtain:—

for $x = 100^{\text{km}}$, ... $V_1 = 4{,}6\frac{\text{km}}{\text{sec.}}$;

,, $x = \infty$,.......... $V_1 = 6{,}1$,, .

Thus it seems probable that even at a comparatively short distances of a few hundred kilometres from the seismic origin, there exists a velocity of 5 or 6 $\frac{\text{km}}{\text{sec.}}$.

§ 57. Whether the velocity V_1 considered in the preceding § really exists or not remains to be settled by future investigations. In the meanwhile it seems pretty certain that the velocity of the 1st preliminary tremor in earthquakes of x between 500 and 2000 km is tolerably high. Thus eleven *strong* and *weak* earthquakes in Japan observed in 1899-1902 and the two severe Manila (Mindanao) earthquakes in 1901-1902 give the following results.

TABLE XLVII.

THE TRANSIT VELOCITY OF THE 1ST PRELIMINARY TREMOR OF EARTHQUAKES OF NEAR ORIGIN.

Date.	Time of occurrence in Tokyo. (1st Normal J. T.)	Origin.	Approximate distance between Tokyo and seismic origin.	Velocity of 1st prel. tremor.*	
	h m s		km	km/sec.	
March 24, 1899	1 02. 35 p.m.	Kyushu.	900.	7.6	mean 8.2
Nov. 25, „	3. 45. 24 a.m.			7.0	
Feb. 2, 1900	5. 04. 23 p.m.			5.5	
June 9, „	9. 12. 45 p.m.			11.5	
May 8, „	11 21. 31 a.m.			9.0	
Dec. 11, 1902	5. 08. 09 a.m.			8.6	
June 8, 1900	5 23. 58 p.m.	Hokkaido.	600-900.	7.8	mean 6.6
June 13, 1902	9. 23 39 a.m.			6.0	
May 28, „	6. 03. 45 p.m.			6.0	
March 20, 1902 (2 eqkes.)	11. 02. 52 a.m. 11. 23. 17 a.m.	Formosa.	2200.	**10.6**	mean 9.2
Nov. 21, „	4. 07. 46 p.m.			7.7	
Dec. 15, 1901	8. 03. 16 a.m.	Manila.	3050.	**10.3**	mean 10.9
Aug. 21, 1902	8. 21. 53 a.m.			**11.5**	

Mean.........about $9\frac{\text{km}}{\text{sec.}}$

The above calculations have been made by the formula

$$\text{velocity}=\frac{t_0-t}{x},$$

where x and t are respectively the distance of the origin from Tōkyō and the time of commencement of the seismic disturbance at the latter *accurately* determined from the diagrams given by the horizontal pendulum apparatus; and t_0 denotes the mean of the times of earthquake occurrence registered by the Gray-Milne type seismographs at the different meteorological observatories in the vicinity of the seismic origin. (In the cases of the two Manila earthquakes, t_0 was

* The more reliable of the resalts are prined in fat letters.

the time at the Manila Observatory indicated by the Vicentini seismograph.) The time t_0, which depends to some extent on the sensibility of the contact-maker of each seismograph, would be subject to some enor. The latter would, however, be very small, as the earthquakes chosen were each sufficiently strong and felt *strongly* or *weakly* in the epicentral district. The result here obtained, which is to be regarded only as a *very rough approximation*, shows nevertheless that the transit velocity for $x=600$ to 3000 km is probably some 9 km per sec.

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