Seismological Investigations.—Fourth Report of the Committee, consisting of Professor J. W. JUDD (*Chairman*), Mr. JOHN MILNE (*Secretary*), Lord KELVIN, Professor T. G. BONNEY, Sir F. J. BRAMWELL, Mr. C. V. BOYS, Professor G. H. DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Professor J. A. EWING, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Professor J. H. POYNTING, Mr. CLEMENT REID, Mr. G. J. SYMONS, *and* Prof. H. H. TURNER. *Drawn up by the Secretary.*

CONTENTS.

I. *On Seismological Stations already established.*

INSTRUMENTS of the same type have been forwarded to the following twenty-three stations :—Shide, Kew, Toronto, Victoria, B.C., San Fernando (Spain), Madras, Bombay, Calcutta, Batavia, Mauritius, Cape Town, Arequipa, Strathmore College (Philadelphia), Tokio, Cordova (Argentina), New Zealand (two instruments), Cairo, Paisley, Mexico, Beyrout, Honolulu, and the last to Trinidad.

It is expected that shortly instruments will be installed in Ireland, New South Wales, and Victoria, and your Secretary has had correspondence about the establishment of seismographs in other countries.

The following Report contains registers from the first eleven of the above-mentioned stations, and reports from several of the remainder are expected to arrive shortly.

The principal analysis of these registers has been made in reference to the one from Shide, but as many earthquakes have been recorded which did not reach that station, but were common to groups of observatories in other parts of the world, it is evident that if similar analyses are made in reference to other localities, our knowledge respecting the distribution of seismic disturbances will be largely increased. Should any of the observers who have forwarded copies of their observations to Shide consider it advisable to undertake this work, it is hoped that this report will be of assistance in carrying out the same.

The Committee thank the Directors of observatories in Italy, Germany, and Russia for copies of records corresponding to those obtained in Shide. For the purpose of seeing the installation in the Isle of Wight and discussing records, Shide has been visited by Colonel Gore, R.E., of the Trigonometrical Survey of India, Mr. R. D. Oldham, of the Geological Survey of that country, Dr. Figee, in charge of the instrument in Batavia, Mr. T. F. Claxton, Director of the Observatory in Mauritius, Dr. F.

Omori, in charge of Seismological Observatories in Japan, Mr. T. Heath, of the Royal Observatory, Edinburgh, and by many others directly or indirectly interested in the work of this Committee.

II. *Notes respecting Observing Stations and Registers obtained from the same.*

1. *England: Isle of Wight, Newport, Shide.* *Observer*, Mr. J. MILNE.

The continuity of records obtained from this station has largely been dependent upon the interest shown in the work by Shinobu Hirota, Mr. Milne's assistant.

At rare intervals, usually in consequence of some irregularity in the band of bromide paper, the clock driving the same has been stopped. Failures due to this cause have been extremely few. The greater number of failures arise from 'air tremors,' which during the winter months, in frosty weather, and at night are frequent. Slight continuous movements of the boom produced by these air currents have no doubt eclipsed many small earthquakes, and have certainly hidden the commencement of larger disturbances. These difficulties, which occur from time to time, and interfere with observations for at least one month out of twelve, are not likely to be overcome until the instrument is moved to a larger and better ventilated room.

A pair of horizontal pendulums recording on smoked paper have given records of the periods of earth vibrations.

The Shide Register.

The following register is compiled from the photographic records of a Milne Horizontal Pendulum, and refers to E.W. displacements. The time used is Greenwich Mean Civil Time. Midnight=24 or 0 hours.

Amp. = Amplitude, or half the complete range of motion. It is expressed in millimetres. 1 mm. = 0″·5 of arc. Records of ·5 mm. or less refer to a mere thickening of the line, and indicate half its width.

D = Duration expressed in hours, minutes and seconds.

P.T.'s = Preliminary Tremors, the duration of which is from the first movement to the maximum motion.

L.W.'s = Large waves, and refers to the maximum motion.

Doubtful means that it is not certain that the record refers to earthquake motion.

The instrument stands on a brick pier founded on the upended beds of hard chalk.

No.	Date		Time of Commencement	Remarks
			1898.	
			H. M. S.	
170	Feb.	27	11 7 44	Amp. ·25mm. D 4m.
171	Mar.	3	15 37 34	Doubtful.
172	„	4	16 53 35	„
173	„	4	21 13 46	Amp. ·25mm. D 6m.
174	„	5	16 35 12	Doubtful.
175	„	17	16 44 22	„
176	„	19	4 45 29	Amp. ·25mm. D 2m.
177	„	21	22 51 50	Thirteen small group up to 1h. 30m. on 22nd. Max. about 0h. 30m.
178	„	23	20 48 6	Amp. ·25mm. D 2m.

THE SHIDE REGISTER—*continued.*

No.	Date	Time of Commencement	Remarks
		H. M. S.	
179	Mar. 28	17 44 28	Amp. ·5mm. D 4m.
	„ 28	18 11 55	„ „ „ 3m.
	„ 28	18 21 5	„ „ „ „
	„ 28	23 44 5	„ ·25mm. „ „
180	„ 29	0 5 11	„ „ „ 7m.
	„ 29	13 33 0	This is the first of at least 28 distinct disturbances, with durations of from 2 to 6 minutes. Those marked with an asterisk commenced gently, and the others abruptly. The largest of the series is that at 15h. 56m. 12s., which has an amplitude of 1mm., and a duration of 7m. Other marked members in the series are at 15h. 29m. 30s., 17h. 23m. 2s., and 18h. 54m. 33s. Many of these are of doubtful character.
	„ 29	15 29 30*	
	„ 29	15 46 36	
	„ 29	15 49 48	
	„ 29	15 56 12*	
	„ 29	16 13 16	
	„ 29	16 39 18	
	„ 29	16 53 32	
	„ 29	17 3 42	
	„ 29	17 13 52	
	„ 29	17 15 54	
	„ 29	17 23 2*	
	„ 29	17 27 6	
	„ 29	17 58 37	
	„ 29	18 12 51	
	„ 29	18 27 6	
	„ 29	18 54 33*	
	„ 29	19 35 14	
	„ 29	19 38 17	
	„ 29	20 12 51	
	„ 29	20 27 6	
	„ 29	20 30 9	
	„ 29	21 56 35	
	„ 29	22 1 40	
	„ 29	22 8 47	
	„ 29	22 43 22	
	„ 29	22 51 30	
	„ 29	23 0 39	
181	„ 30	12 7 0	Amp. 1mm. D 6m.
182	„ 31	8 21 1	Maxima at 5·7, and 11m. later. Amp. 1mm. D 24m.
183	„ 31	11 24 56	Doubtful. Amp. ·5mm. D 10m.
184	„ 31	13 15 42	The first of a series of 22 very slight shocks, ending at 5 P.M. Greatest amp. 1mm.
	„ 31	13 45 12	
	„ 31	13 59 26	
	„ 31	14 15 42	
185	April 3	7 38 35	Amp. ·5mm. D 10m.
186	„ 4	11 42 11	„ ·25mm. „ 5m.
	„ 4	12 24 53	„ ·5mm. „ „
	„ 4	12 39 8	„ ·25mm. „ „
187	„ 5	14 30 0	From 13·30 to 15·30. About 12 small disturbances; each commences suddenly. The one at 14·30 has 2 max. each ·5mm. D 8m.
188	„ 6	12 37 17	Ten min. later a max. amp. 2mm. Small P.T.'s 6m. D 35m.
189	„ 15	7 47 55	Six min. later a max. amp. 2mm., 7m. still later another, max. 1·5mm. D 54m. Small P.T.'s 4m.
190	„ 15	22 15 31	Amp. ·5mm. D 3m.
191	„ 18	17 51 31	„ „ „ „

THE SHIDE REGISTER—*continued.*

No.	Date		Time of Commencement.	Remarks
			H. M. S.	
192	April	23	9 8 49	Five min. later a max. amp. 1mm. Small P.T.'s 3m. D 16m.
193	„	23	23 58 55	Thirty-six min. later a max. amp. 6mm. Small P.T.'s 25m. D about 2h. Commencement earlier than noted.
194	„	25	17 55 27	Doubtful.
195	„	25	11 14 17	Amp. ·25mm. D 5m. } Six or eight similar disturbances between these two.
	„	25	12 25 10	„ „ „ „
196	„	29	16 39 4	Continuous to 17h. 37m. 34s., with at least 7 max. each 1mm.
197	May	1	10 33 0	Doubtful.
198	„	7	4 9 55	Seven other small shocks up to 5.30. Amp. ·25 to ·5mm. D 2 to 5. All doubtful.
199	„	7	6 4 6	Thirty-five min. later a max. amp. 1·75mm. Motion rises and falls every 5 to 9m. for 2h.
200	„	20	23 29 5	Amp. 1mm. D 5m.
201	„	22	17 28 15	} Amp. 1mm. and D for each about 5m.
	„	22	18 31 15	
	„	22	19 20 15	
202	„	22	22 50 0	
203	„	22	1 31 21	Amp. ·75mm. D 8m.
204	„	30	1 16 54	„ ·25mm. „ 1m.
205	„	30	1 30 54	„ „ „ „
206	„	30	2 56 54	„ „ „ „
207	„	30	4 18 55	„ ·1mm. „ 10m.
	„	30	5 30 0	„ „ „ 5m.
208	„	30	12 57 50	„ ·25mm. „ 2m.
209	„	31	1 38 51	„ ·5mm. „ 3m.
210	June	3	17 14 44	„ „ „ 10m.
211	„	19	7 8 50	„ ·25mm. „ 3m.
212	„	20	18 52 47	„ ·5mm. „ 6m.
213	„	21	0 46 42	Fourteen min. later amp. 2·5mm. Small P.T.'s 12m. D extends 2h.
214	„	22	6 52 42	} From a series of 10 max. each with amp. ·25 to ·5 mm. D 5m.
	„	22	7 14 42	
	„	22	7 39 42	
	„	22	9 7 42	
215	„	29	18 48 37	Forty min. later a max. amp. 8mm. Small P.T.'s 9m. D 3h. The seismogram shows a marked symmetry. Period of L.W.'s 23s.
216	July	2	4 27 24	Max. amp. ·5mm. D 4m.
217	„	2	17 3 23	„ „ 1mm. „ 8m. Doubtful.
218	„	3	21 42 23	Amp. ·5mm. D 5m.
219	„	12	10 30 0	Max. amp. ·75mm. D 5m Doubtful.
220	„	13	23 51 8	„ „ ·5mm. „ 3m.
221	„	14	17 46 15	„ „ 1·25mm. „ 40m. Small P.T.'s 14m.
222	„	20	16 59 26	„ „ ·75mm. „ 45m.
223	„	21	11 35 56	„ „ ·25mm. „ 4m.
224	„	26	23 21 14	Amp. ·25mm. D 3m.
225	Aug.	8	8 53 30	Max. amp. 1mm. D 35m.
226	„	19	1 51 12	„ „ 25mm. „ 3m.
227	„	20	16 4 19	Amp. ·25. D 2m.
228	„	21	17 28 0	Max. amp. 2·5mm. D 2m.
229	„	22	23 39 3	„ „ 4mm. „ 17m. Doubtful.
230	„	31	20 5 2	„ „ 10mm. „ 3h. Smallest P.T.'s 5m. Max. 31m. from commencement. Shows symmetry. Period of L.W.'s 32s.

THE SHIDE REGISTER—*continued.*

No.	Date		Time of Commencement	Remarks
			H. M. S.	
231	Sept.	3	16 4 48	Max. amp. 1·25mm. D 56m.
232	,,	13	18 11 37	Slight thickenings until 20h. 7m. 35s.
	,,	13	20 7 35	
233	,,	22	12 30 54	A series of 6 max. with amps. reaching 3mm. D for each 3 to 5 m.
	,,	22	13 37 52	
234	,,	25	12 51 50	Amp. ·5mm. D 13m.
235	Oct.	11	16 58 52	Max. amp. 1·5mm. D 1h. 40m. About 19 maxima.
236	,,	11	19 26 38	Amp. ·25mm. D 2m.
237	,,	12	13 21 2	,, ,, ,, ,,
238	,,	15	4 2 44	Max. amp. ·5 mm. D 7m.
239	Nov.	17	13 20 15	,, ,, ,, ,, 35m.
240	Dec.	1	12 48 16	,, ,, ,, ,, 55m. About 11 thickenings.
241	,,	3	3 18 43	Amp. ·25 mm. D 1m.
242	,,	3	6 25 53	,, ,, ,, 5m.
243	,,	3	17 42 26	,, ,, ,, 2m.
244	,,	4	20 20 40	,, ,, ,, 2m.
				1899.
245	Jan.	6	19 11 9	Max. amp. ·25mm. D 20m.
246	,,	12	3 58 18	,, ,, ·75mm. ,, 6m.
247	,,	12	9 2 26	,, ,, ·25mm. ,, 12m.
248	,,	14	2 48 55	,, ,, 2·5mm. ,, 50m. Two shocks, the second from 3h. 25m. 30s.
249	,,	22	8 22 53	Max. amp. 1mm. D 30m.
250	,,	24	23 47 42	,, ,, 6mm. ,, 80m. Commencement and end uncertain.
251	,,	30	18 55 52	Amp. ·25mm. D 1m.
252	,,	31	11 22 47	Max. amp. 1mm. D 20m.
253	,,	31	17 32 31	,, ,, ·25mm. ,, 8m.
254	Feb.	23	13 47 23	,, ,, ·75mm. ,, 10m.
255	,,	26	13 47 29	,, ,, 1mm. ,, 12m.
256	,,	27	10 12 19	,, ,, 2mm. ,, 28m. Two shocks.
257	,,	27	15 26 40	,, ,, 1mm. ,, 5m.
258	,,	28	16 7 14	Amp. ·25mm. D 3m.
259	,,	28	19 47 38	Max. amp. ·75mm. D 15m.
260	,,	28	23 1 5	,, ,, ·25mm. ,, 6m.
261	Mar.	6	15 32 52	Amp. ·25mm. D 15m.
262	,,	6	20 52 31	,, ,, ,, 7m.
263	,,	7	1 31 1	Max. amp. 1·5 mm. D 80m. Commencement and end uncertain.
264	,,	12	9 55 10	Max. amp. 1mm. D 50m.
265	,,	17	19 44 48	Amp. ·25mm. D 4m.
266	,,	19	13 45 35	,, ,, ,, 10m.
267	,,	21	14 58 47	,, ·5mm. ,, 43m. Max. at 15h. 39m. 8s.
268	,,	23	10 45 16	,, 1·5mm. ,, 1h. 38m. Max. at 11h. 16m. 16s. Small P.T.'s 28m.
269	,,	23	14 57 41	Amp. ·75mm. D 44m. Max. at 15h. 0m. 47s. Small P.T.'s 1m. 2s.
270	,,	25	14 53 19	Amp. ·5mm. D 45m. Max. at 15h. 21m. 14s.
271	,,	25	20 39 52	Amp. ·25mm. D 3m.
272	April	3	11 1 6	,, ·5mm. ,, 12m.

The preceding part of this List is contained in the 'British Association Report' for 1898, pp. 179–276.

In its original form the above List did not contain records numbered 170, 173, 176, 177, 178, 190, 191, 198, 204, 205, 206, 208, 209, 211, 212, 218, 224, 227, 234, 236, 237, 241, 242, 243, 244, 251, 258, 261, 262, 265, 266, 267, 268, 269, 270, 271, and 272. The reason for the omission was that these records were so small that it was not considered likely that they would be recorded at other stations. I call them the subsidiary list.

Between March 18 and 21 the original list was sent to stations No. 1 to 19,[1] and also to Strassburg, Padua, Rome, Rocca di Papa, Casamicciola, Catania, Potsdam, Nicolaiew, Edinburgh and Bidstone.

On April 14 the subsidiary was forwarded to Cadiz, Bombay, Toronto, Potsdam, Rome, Rocca di Papa, Catania, Paisley and Kew.

The responses have, when necessary, been reduced to Greenwich mean civil time, and are contained in the following tables :—

2. *England: Kew Observatory. Superintendent*, Dr. CHARLES CHREE, *F.R.S.*

Kew has met with difficulties in common with Shide, but the tremors have not been so frequent or pronounced. Why certain earthquakes like Nos. 196, 207, 214, 220, 221, 225, 246, 247, &c., were not recorded, whilst the amplitudes of large earthquakes are smaller than the same at Shide and at the same time show phases of maxima movements farther separated in time than they appear to be at the latter place, is difficult to understand. The most likely explanation is that at Kew the foundations of the instruments rise from an extremely thick bed of soft tertiary materials more or less saturated with water, whilst at Shide the piers rise from the surface of upended beds of comparatively hard, dry chalk.

The Kew Register.

Such a statement as 'normal line or line, ·2 mm.; tremors, 0·4 mm.' means that the full width of the line (*not* the half width) was ·2 mm. when undisturbed, but ·4mm. when disturbed. In such a case the amplitude would be $\frac{1}{2}$ (·4 − ·2), or ·1 mm. On the other hand, when it is said either that 'max. amplitude = 0·9 mm.,' or 'amplitude = 5·5 mm.,' it is meant that the half width of the central line was 0·9 in the former and 5·5 in the latter case. The *true* amplitude would be in the former case, say, 0·9 − x, when $2x$ was the undisturbed width of the line, whatever that might be at the time.

At Kew variations in the full width of the line from ·1 to ·3 mm. are noticed.

Milne Seismograph started at Kew Observatory on April 19, 1898.

No.	Shide No.	Date	Time of Commencement		Remarks: (D = duration in minutes)
			1898.		
			H.	M.	
1	195	April 25	11	5·9	Character slight. D = 2. Faint tremors 11h. 14m. to 11h. 24m.
	—	„ 28	15	3·9	Fairly well marked. D = 12. Max. tremor 0·4 mm.

[1] See *British Association Report*, 1898, pp. 180–182.

THE KEW REGISTER—*continued.*

No.	Shide No.	Date	Time of Commencement	Remarks: (D = duration in minutes)
			H. M.	
3	—	April 29	8 5·7	Slight. D = 2. Normal line = ·2 mm. Max. tremor = ·5 mm.
4	199	May 7	6 4·0	Very faint tremors at intervals from 6h. 4m. to 6h. 41m. Most marked at 6h. 10·5m. and 6h. 39m.
5	—	„ 8	8 37·3	Slight. D = 2. Normal line = ·2 mm. Tremor = 0·4 mm.
6	—	„ 10	15 49·2	Slight. D = $2\frac{1}{2}$. Normal line = ·2 mm. Tremor = 0·5 mm.
7	—	„ 11	12 3·1	Slight. D = 2. Normal line = ·2 mm. Tremor = 0·4 mm.
8	—	„ 17	8 37·7	Slight. D = 2. Normal line = ·2 mm. Tremor = 0·5 mm.
9	—	„ 21	12 45·5	Very slight; little more than a broadening of the line.
10	—	„ 22	11 54·5	„ „ „
11	—	„ 22	12 43·0	„ „ „
12	—	„ 23	14 7·4	„ „ „
13	—	„ 27 „ 27 „ 27	2 58·6 3 7·2 3 21·7	Slight pulsations for about 35min. Max. at 3h. 15m.
		„ 30 & 31	—	Boom 'off' greater part of time.
14	—	June 1	16 18·2	Small movement. D = 3. Line = ·15 mm. Tremor = 0·4 mm.
15	210	„ 3	17 10·7	Fairly well marked. D = 8. Max. at 17h. 14·5m.
16	—	„ 13	14 22·8	Very slight. D = 5.
17	—	„ 17	18 41·7	„ „ D = $2\frac{1}{2}$.
18	211	„ 19	7 8·4	Little more than a broadening of the line.
19	213	„ 21	0 46·3	Fairly well marked movement. D = 64·8. Max. at 0·59·1, with a sudden movement. Max. amplitude = 0·9 mm. = 0″·55, followed by slowly decreasing tremors till 1h. 51·1m.
20	—	„ 21	19 2·8	Slight. D = 4m. Normal line = ·2 mm. Tremor = ·4 mm.
21	214	„ 22	6 54·4 7 12·2 7 36·5	A long series of slight tremors, the times given being for the commencement of the major movements, but there was almost constant movement till apparently 9h. 6·5m.
22	215	„ 29	18 47·2	The largest disturbance recorded here during 1898. The maximum movement was at 19h. 21·6m., with an amplitude of 5·5 mm. = 3″·36 of arc; the next largest swing occurred at 19h. 26·2m., with amplitude of 5 mm. The movements grew smaller and smaller until 20h. 4·2m., but there were numerous tremblings up to 21h. 8·6m.
23	216	July 2	4 25·4	Short, but well defined. Began suddenly, with almost no preliminary tremor. Max. was at 4h. 28·5m., with an amplitude = 0·5 mm.
24	217	„ 2	16 25·8	Very slight. D = $4\frac{1}{2}$.

THE KEW REGISTER—*continued.*

No.	Shide No.	Date	Time of Commencement	Remarks: (D = duration in minutes)
			H. M.	
25	218	July 3	21 44·5	Very slight. D = 2.
26	—	„ 13	18 3·0	Succession of slight tremors, lasting for 15m.
27	—	„ 15	22 9·3	*Very* slight; little more than a broadening of the line.
28	223	„ 21	11 35·0	Very slight.
29	—	„ 22	14 2·5	Slight. D = 3. Line ·15 mm. Tremor = ·3 mm.
30	—	„ 25	14 36·1	Slight. D = 7. Line ·2 mm. Tremor = ·6 mm.
		Aug. 13–28	—	Action of boom doubtful. ? Grazing scale plate.
31	—	„ 30	15 39·3	*Very* slight; a mere broadening of the line.
32	230	„ 31	20 4·0	Large disturbance, lasting for 1h. 33·6m. Max. amplitude = 5·5 mm.
33	—	Sept. 3	9 0·3	*Very* slight. D = 1½. Line ·2 mm. Tremor ·4 mm.
34	231	„ 3	15 54·0	*Very* slight. End at 16h. 14m.
35	232	„ 13	18 11·3	*Very* slight.
36	—	„ 20	12 28·4	Very slight. D = 1½. Line ·2mm. Tremor ·4mm.
37	233	„ 22	12 46·5	Long periods of small swings, lasting from 12h. 46·5m. to 2h. 9·8m. Maxima at 1h. 10m., 1h. 39·4m., and 1h. 44·2m. Max. amplitude = 0″·31.
38	234	„ 25	0 50·3	Small. D = 13. Max. at 0h. 53m. Line ·3 mm. Tremor ·8 mm.
39	—	„ 28	17 40·0	? Tremor or light flare. D = 1½.
40	—	„ 29	14 48·8	*Very* slight; just a broadening of line for 3m.
41	235	Oct. 11	16 59·2	Fairly well marked period of small swings, lasting 1h. 16m. Max. at 17h. 38·7m. and 17h. 45.3m. Amplitude = 0″·33.
42	237	„ 12	13 20·6	Small. Preliminary tremors 2·5m. Max. at 13h. 23·5m., with amplitude = 0″·30.
43	238	„ 15	4 28·0	Slight. D = 3. Line ·15 mm. Tremor ·5 mm.
44	239	Nov. 17	13 37·2	Movement well marked, but swings not large. Preliminary tremors 10·8m. Max. at 13h. 46·4m. and 13h. 58·6m. Total D = 53. Max. amplitude = 0″·60.
45	240	Dec. 1	12 51·6	Very slight. D = 24.
46	241	„ 3	3 1·3	Very slight; scarcely more than a broadening of line.
		„ 3	3 7·0	„ „ „
			1899.	
47	245	Jan. 6	19 37·0	Slight. D = 15. Line ·4 mm. Tremor ·8 mm.
48	—	„ 6	19 41·5	Slight ripples lasting, say, for 28 mins., with max. at 20h. 4·2m. Line ·5 mm. Tremor 1 mm.

THE KEW REGISTER—*continued.*

No.	Shide No.	Date	Time of Commencement	Remarks: (D = duration in minutes)
			H. M.	
49	248	Jan. 14	2 58·2	Well-marked disturbance. First max. at 3h. 26·5m., second at 3h. 28·2m. Max. amplitude 1·75 mm. = 1″·03. Total duration 1h. 11·3m. (Duration of preliminary tremors 27·2m.)
50	249	" 22	8 22·2	Short, but well marked. Max. at 8h. 29m., with amplitude 0″·77. D = 27·5. (Preliminary tremors 5·6m.)
51	—	" 22	19 52·6	Slight. D = 3. Line ·4 mm. Tremor ·7 mm.
52	250	" 24–25	23 47·6	Large and distinct movement. First max. at 0h. 35·5m. on 25th, with amplitude 2″·14; second max. at 0h. 42·6m., with amplitude 2″·44. The amplitude exceeded 0″·5 till 1h. 10m., and then died down very gradually. Total D = 2h. 59·6m. (Preliminary tremors 43·4m.)
53	251	" 30	18 45·8	Only a broadening of the normal line.
54	252	" 31	11 21·8	A short but distinct movement, dying off very gradually. Max. at 11h. 25m. Amplitude = 0″·30. D uncertain, probably 21m.
55	253	" 31	17 31·3	*Very* small; just a broadening of line. D from 2–4.
56	—	Feb. 1	10 27·7	" " "
			12 42·7	" " "
			13 9·0	" " "
57	—	" 1	21 43·7	" " "
58	—	" 2	10 42·8	" " "
			11 16·9	" " "
59	—	" 12	12 12·0	Slight. D = 2½. Normal line ·4 mm. Tremor ·8 mm.
60	254	" 23	13 49·5	Slight. D = 6. Normal line ·3 mm. Tremor ·6 mm.
61	255	" 26	13 49·0	*Very* slight; just a thickening of line. D = 9 mm.
62	256	" 27	11 27·5	Small movement. D = 25. Line ·3 mm. Trace 1·0 mm.
63	257	" 27	15 27·2	*Very* slight. D = 3.
64	—	" 28	7 7·2	Slight. D = 8. Line ·3 mm. Tremor ·8 mm.
65	259	" 28	19 48·5	Slight. D = 6. Line ·3 mm. Tremor ·8 mm.
66	262	Mar. 6	20 36·7	Very slight. End at 21h. 9·2m.
67	263	" 7	1 17·7	A short series of small movements, lasting from 1h. 17·7m. to about 2h. 11·8m. Max. at 1h. 53·4m. Line ·2 mm. Tremor ·8 mm.
			1 23·5	
			1 41·8	
68	264	" 12	9 55·7	Faint suspicion of movement.
69	—	" 15	12 28·9	Small. D = 2. Line ·1 mm. Trace ·5 mm.
70	—	" 16	12 0·5	" D = 1½. " ·2 mm. " ·5 mm.
71	267	" 21	15 25·5	Trace rather ill-defined, focus not being good, but apparently lasted about 12m. Character slight.
72	—	" 22	22 15·7	Slight. D = 4. Normal line ·2 mm. Trace ·5 mm.

THE KEW REGISTER—*continued.*

No.	Shide No.	Date	Time of Commencement		Remarks: (D = duration in minutes)
			H.	M.	
73	268	Mar. 23	11	0·5	A series of small swings. Total duration 45m. *First max. 11h. 20·2m.*, second at 11h. 22·2m. Max. amplitude = 0″·30.
74	269	„ 23	15	0 4	Small. D = 18·5. Max. at 15h. 14·7m. Line ·2 mm. Tremor ·8 mm.
75	—	„ 24	4	53 6	Slight movements on and off till 5h. 30m. Line ·4 mm. Tremor ·9 mm.
76	270	„ 25	14	54 0	Distinct movement.
77	271	„ 25	20	46 1	Merely a broadening of the line. (No further movements during March, 1899.)

3. *Canada: Toronto. Meteorological Observatory.*
Professor R. F. STUPART, *Director.*

The instrument has been moved from the small building outside the Magnetic Observatory to the inside of the same. One result is that air tremors have apparently entirely disappeared. The Observatory is situated on a bed of alluvium, perhaps 100 feet in thickness and stretching 20 miles North, East, and West with Lake Ontario on the South. Beneath the alluvium are granitic and other primitive rocks.

The purchase money for the Toronto instrument and the funds required for the installation and maintenance of the same, and also for the installation of a seismograph at Victoria, B.C., have been provided by the Dominion Government. The excellent series of results obtained from these stations, amongst other things, throw light upon changes taking place along the Eastern and Western Canadian seaboards. They have already attracted the attention of scientific men, and will undoubtedly act as an incentive for other Governments to work on similar lines.

The Toronto Register.

No.	Shide No.	Date		Commencement	Maximum	End	Amp.	Remarks
				1897.				
				H. M. S.	H. M. S.	H. M. S.	MM.	
1	133	Sept.	20	19 24 0	—	Aircurrents	—	—
2	—	„	21	—	6 53 30	—	—	—
3	—	„	25	15 16 16	15 17 0	15 20 16	0·5	—
4	—	Oct.	13	20 05 30	—	—	0·2	—
5	—	„	13	22 14 0	Thickening of line.		Dur. 4m.	
6	—	Nov.	10	14 58 0	15 2 0	15 7 0	0·7	—
7	—	„	19	6 21 19	6 23 19	Aircurrents	—	—
8	153	Dec.	11	10 0 0	10 3 0	10 36 0	1·0	—
9	—	„	19	14 38 0	14 38 0	—	—	—
10	156	„	28	20 24 37	30 31 40	20 54 20	2·0	—
11	157	„	29	11 32 29	11 35 31	12 35 0	6·9	—
				1898.				
12	—	Jan.	20	0 54 0	0 58 22	1 2 0	0·3	—
13	161	„	25	0 13 30	0 29 0	1 3 0	6·8	—

THE TORONTO REGISTER—*continued.*

No.	Shide No.	Date	Commencement	Maximum	End	Amp.	Remarks
			H. M. S.	H. M. S.	H. M. S.	MM.	
14	—	Mar. 20	12 48 38	12 51 8	13 19 0	2·0	—
15	—	„ 25	—	20 18 0	—	1·5	—
16	—	„ 29	15 35 30	15 38 27	15 41 29	0·2	—
17	188	Apr. 6	12 44 40	12 54 44	13 3 12	5·0	Well marked.
18	189	„ 15	Air currents	7 26 40	Air currents 22nd.	2·0	Well marked.
19	—	„ 21	22 42 41	23 24 7	0 39 43 23rd.	2·2	—
20	193	„ 22	23 59 50	0 34 26 23rd.	1 49 12	3·9	Very pronounced.
21	196	„ 29	16 28 20	16 35 5	17 9 46	7·2	—
22	199	May 7	6 0 42	6 16 40	Air currents	5·2	Large shake.
23	—	„ 27	{ 2 26 47 / 2 27 57 }	2 32 12	Uncertain	2·0	Moderate.
24	215	June 29	18 43 41	18 55 18	20 43 41	16.	Very large.
25	—	July 11	Small displacements 20 h. and 23h. About 15m.				
26	—	„ 20	Uncertain	17 2 33	Uncertain	1·0	—
27	—	„ 23	23 10 31	23 24 0	23 30 0	0·5	Small but decided.
28	—	„ 24	19 56 54	19 59 0	Uncertain	0·5	Small.
29	—	„ 25	15 31 39	15 39 0	16 40 0	1·0	Moderate, four distinct shocks.
30	—	Aug. 4	4 5 21	4 5 21	4 23 17	0·3	—
31	—	„ 16	10 39 5	10 45 50	10 48 50	1·0	Three distinct shocks.
32	230	„ 31	20 17 53	21 3 20	22 12 36	1·1	Series of small shocks.
33	231	Sept. 3	16 17 22	16 18 30	16 31 20	0·2	Very small.
34	232	„ 13	18 21 45	19 15 44	21 11 0	2·1	Moderate.
35	—	„ 25	9 45 2	9 53 32	10 1 0	0·3	Small.
36	—	„ 25	18 56 37	18 57 32	19 16 50	0·7	Small.
37	235	Oct. 11	16 47 29	17 29 30	17 47 29	3·6	Large.
38	—	„ 22	0 51 18	—	—	—	Very small.
39	239	Nov. 17	13 9 46	13 44 50	14 44 2	1·5	Marked.
40	—	„ 27	1 24 1	—	—	—	Very small.
41	—	Dec. 5	A noticeable thickening of the line at 16h. 7m.				
42	—	„ 11	7 33 15	—	—	—	Decided, but small.
43	—	20	8 2 55	—	—	—	Thickening of the line.
44	—	„ 23	{ 5 26 55 / 5 40 8 }	—	—	0·1 {	Two very small ones.
45	245	Jan. 6	19 9 8	Uncertain	19 57 0	—	Succession of small shocks.
46	246	„ 12	3 47 50	—	—	0·4	Very small, but decided.
47	248	„ 14	2 42 18	2 57 6	4 8 51	3·2	Moderate.
48	—	„ 24	12 14 59	—	—	—	Very small.
				1899.			
49	250	Jan. 24	23 50 24	0 12 10	2 27 28	9·5	Large.
50	252	„ 31	11 36 0	11 37 12	12 22 42	0·2	—
51	—	Feb. 7	—	22 4 0	—	—	Minute.
52	—	„ 8	19 24 14	19 34 23	19 58 14	0·5	Very small.
53	254	„ 23	Air currents	14 4 0	—	0·5	Very small.

THE TORONTO REGISTER—*continued.*

No.	Shide No.	Date	Commencement	Maximum	End	Amp.	Remarks
			H. M. S.	H. M. S.	H. M. S.	MM.	
54	256?	Feb. 27	11 41 10	11 42 20	—	1·0	Very small.
55	259	" 28	20 0 15	20 1 0	20 8 0	0·3	Very small.
56	263	Mar. 7	1 19 29	2 1 0	2 19 29	0·5	Small.
57	264	" 12	9 52 11	9 58 7	10 52 11	3·5	Moderate.
58	266?	—	—	—	—	—	—
59	268	" 23	10 41 52	11 6 0	11 41 52	0·6	Small.
60	269	" 23	Thickening of line at 14h. 45m. 47s.				Duration, 20m.
61	—	" 24	5 9 18	—	5 14 18	0·3	Very small.
62	270	" 25	14 44 37	14 46 57	—	0·5	P.T.'s marred by air currents.
63	—	Apr. 5	8 33 38	Thickening of line uncertain.			
64	—	" 12	17 55 0	17 59 4	19 34 3	0·6	Small.
65	—	" 13	4 9 8	4 11 0	4 31 8	0·4	Very small.
66	—	" 14	6 56 43	7 2 37	7 7 45	0·6	Very small.
67	—	" 16	13 48 59	14 2 48	15 22 10	7·0	Large and continuous.
68	—	" 17	2 2 11	3 0 0	3 0 50	0·6	Series of small shocks.
69	—	May 8	3 50 22	3 51 22	4 47 0	0·3	Very small.
70	—	" 12	15 44 5	15 46 0	15 54 0	0·4	Small.
71	—	June 5	4 38 42	4 54 16	7 3 51	14·7	Very large.
72	—	" 5	15 7 24	15 16 0	17 18 0	10·0	Very large.

Instrument put into basement January 19, 1899.
Double vibration of boom 15 seconds or the same as before.

4. *Canada: Victoria, B.C.* MR. E. BAYNES REID, *Superintendent.*
MR. F. NAPIER DENISON *in charge of the Seismograph.*

The instrument is in the basement of an old brick building with stone foundation on the shore of the harbour. It is placed on a solid concrete pillar, built on bed rock not many yards distant from the water. I am not aware that troubles arising from 'air tremors,' or other causes, have interfered with the regular working of the instrument.

The Victoria Register.

No	Shide No.	Date	Commencement	Maximum	Ending	Amp.	Remarks
			1898.				
			H. M. S.	H. M. S.	H. M. S	MM.	
1	235	Oct. 11	16 44 34	—	—	—	Faint curve.
2	—	" 22	0 40 0	—	1 17 0	2·5	Faint curve.
3	239	Nov. 17	13 7 0	Various places 14h. 50m.		0·5	Series of small shocks.
4	—	Dec. 11	6 53 58	—	—	—	—
5	—	" "	7 13 52	7 25 0	9 19 0	1·2	Medium.
6	—	" "	8 58 7	—	—	—	—
7	—	" 19	10 17 0	Tremors extending 15h. 45m.			Very slight.
8	—	" 20	8 11 0	—	—	—	Minute tremors.
9	—	" 23	1 2 0	—	—	—	Minute tremor.

THE VICTORIA REGISTER—*continued.*

No.	Shide No.	Date		Commencement	Maximum	Ending	Amp.	Remarks
				H. M. S.	H. M. S.	H. M S.		
10	—	Dec.	23	4 1 0	—	—	—	Quake in Victoria. Some sections escaped.
Also on Dec. 1, 13h. to 14h., and again at 19h. 40m. small shakes.								
1899.								
11	246	Jan.	12	3 35 16	3 36 15	3 40 16	0·9	Small.
12	248	,,	14	2 42 30	2 55 28	3 43 30	8·1	Large.
13	—	,,	23	2 0 0	—	—	—	Marked little vibrations, 2h.
14	—	,,	24	12 17 30	12 17 50	12 23 30	0·2	Very small.
					25th.	25th.		
15	250	,,	,,	23 51 7	0 5 36	3 15 0	20.	Very large.
16	252	,,	31	11 40 0	11 41 26	11 46 0	0·1	—
17	—	Feb.	8	19 31 59	19 35 0	19 40 0	0·4	Very small.
18	254	,,	23	14 6 40	14 8 33	14 12 5	0·1	—
19	255	,,	26	14 6 23	14 8 24	14 17 19	0·1	—
20	—	,,	27	15 47 7	15 47 17	15 52 7	0·1	—
21	259	,,	28	Slight thickening of the line 20h. 5m. to 20h. 12m.				
22	263	Mar.	7	1 15 13	1 16 15	2 17 13	0·4	—
23	264	,,	12	9 49 55	9 59 30	10 49 55	0·4	—
24	266	,,	19	13 15 43	—	13 24 43	0·9	—
25	} 268 {	,,	23	10 35 47	11 17 17	12 4 37	1·9	—
26		,,	,,	10 45 51	—	—	—	Very small.
27	269	,,	,,	14 55 20	15 5 11	15 30 48	1·0	—
28	—	,,	24	5 19 39	5 20 54	5 27 15	0·6	—
29	270	,,	25	14 46 25	15 0 12	15 23 16	1·1	—
30	—	April	5	8 18 0	Thickening	of the line	—	—
31	—	,,	6	3 39 46	4 5 13	4 38 52	0·1	Very small shocks.
32	—	,,	12	17 47 4	18 19 0	18 59 35	0·5	Very small vibrations from 13h. 55m.
33	—	,,	13	3 59 15	4 25 59	5 12 28	0·4	Series of small shocks.
34	—	,,	14	7 9 10	7 9 39	7 16 20	0·4	Very small.
35	--	,,	16	13 42 30	Number of vibrations across slit	15 33 42	—	Large and continuous.
36	—	,,	17	1 59 8	2 26 37	3 34 57	1·15	Medium.
37	—	May	8	3 45 36	3 46 36	4 35 31	0·1	Very small.
38	—	,,	15	20 5 21	Thickening of the line	20 16 16	—	Very small, may be air currents.
39	—	,,	25	19 0 0	Thickening	of the li	—	—
Also Jan. 30 about 18h. 44m. 15s. a thickening of the line. Feb. 27 about 10h. 12m. 0s. air current effect.								

From January 7, 1899, swing was increased from 15 to 20 secs. March 25 boom put at 17 secs.; ending March 4, 15 secs.; April 1, 17 secs.; April 8, 17 secs.

5. *Spain: Cadiz. San Fernando. Instituto y Observatorio de Marina. Director*, Commodore J. VINIÈGRA.

When first installed the instrument at this station showed but few movements of the ground, and these were slight. On April 27, 1899, it was therefore dismounted, but set up again on the same day; the position of the balance weight being slightly altered and a more perfect equilibrium of the boom assured. Its period is 16 seconds. Now it appears to work better, but the vibrations are not very intense as compared with those from other localities. This lack of sensitiveness may, Commodore Viniegra remarks, be due to the foundations, in which there are several 'stone furrows,' surrounded with mud.

The San Fernando Register.

No.	Shide No.	Date		Commencement.	Remarks
					1898.
				H. M. S.	
1		Feb.	18	16 25 49	Rapid barometrical fall.
2		„	24	10 54 49	
3	170	„	27	„	Earthquake recorded.
4	172	Mar.	5	16 30 49	Small movements up to 10h.
5	185	April	3	7 44 4	
6	188	„	6	12 36 49	
7	193	„	22	23 59 51	Max. 23h. 0m. 36·6s. *Amp.* 34mm. D 1h. 40m.
8	196	„	29	16 37 19	
9	199	May	7	5 57 49	
10	209	„	31	0 21 30	Rapid deviation of 4 mm.
					June 19–July 21, main-spring of clock broken.
11	230	Aug.	31	„	Earthquake recorded.
12	234	Sept.	13	18 10 49	
13		„		19 19 4	
					September 20–24, not working.
14	235	Oct.	11	17 27 19	
					1899.
15	245	Jan.	6	19 14 4	
16	256	Feb.	2	11 35 49	
17	259	„	28	19 56 49	
18	263	Mar.	7	1 49 49	
19	267	„	21	15 58 19	
20	268	„	23	11 40 34	Rapid deviations to 11h. 56m. and 15h. 42m.
21	270	„	25	14 52 19	
					April 1–4, watch removed and replaced by an electrically moved pencil.
22	290	June	5	4 40 55	
23	291	„	5	15 6 55	
24	293	„	14	11 18 16	
25	299	July	2	12 59 20	
26		„	7	7 0 12	
27		„	7	8 0 2	
28	302	„	7	9 0 42	
29	306	„	11	7 57 22	
30	307	„	12	1 41 12	
31		„	12	15 13 27	
32	308	„	14	12 46 30	
33		„	17	5 17 0	

6. *India: Madras. Director*, Dr. C. Michie Smith.

Dr. C. H. Michie Smith writes as follows :—

'The instrument is placed in the old magnetic room of the Observatory on one of the old piers. The surrounding ground is mainly a stiff clay which cracks during the hot weather, leaving fissures many inches deep. The Observatory is on a plain, and is about three miles from the sea and 20 feet above sea level. No air tremors were experienced during the time under report, but the instrument gave a great deal of trouble specially owing to changes in the length of the suspending silk thread, caused probably by alterations in the amount of moisture in the air. The instrument will be removed to Kodaikanal as soon as a room is ready for it.'

The Madras Register.

No.	Shide No.	Date	Prelim. Tremors begin	Shock begins	Maximum	Amplitude	Shock ends	Final Tremor ends	Remarks
					1898				
			H. M. S.	H. M. S.	H. M. S.	MM.	H. M. S.	H. M. S.	
1	201	May 21 ?	17 14 25	17 20 1	17 20 1	0·75	17 26 5	17 35 38	—
—	201	—	—	19 54 0	—	0·5	19 55 0	—	—
2	210 ?	—	—	—	—	—	—	—	About this time a large number of small disturbances, but none characteristic of a true shock—possibly they were caused by a spider.
—	—	June 4 to Aug. 11	—	—	—	—	—	—	Instrument not working.
3	230	Aug. 31	20 2 5	20 12 25	20 18 0	1·0	20 33 35	20 43 36	—
4	—	Sept. 9	—	3 48 38	—	<0·5	3 40 47	—	—
5	232 ?	„ 13	—	17 34 25	—	—	17 35 37	—	Very slight.
6	233	„ 22	—	12 34 43	—	—	12 39 13	—	„
7	—	„ 25	—	12 24 13	—	—	12 31 19	—	„
8	—	Oct. 1	—	3 27 49	3 29 1	—	3 30 31	—	„
9	235 ?	„ 11	—	17 2 36	—	—	17 59 12	—	Probably due to a thunderstorm.
10	238	„ 15	—	3 50 19	3 52 25	1·2	3 56 40	4 6 26	Felt as a shock in N. India.
11	—	Nov. 12	—	9 47 1	—	—	9 48 31	—	Very slight.
12	—	„ 30	—	12 32 30	—	—	12 35 0	—	„
13	240	Dec. 1	12 45 14	12 52 21	12 55 9	1·0	13 3 43	13 9 11	—
14	—	„ 15	—	12 6 31	—	—	12 10 31	—	Very slight.
15	—	„ 21	—	13 15 31	—	—	13 19 1	—	„
					1899				
16	—	Jan. 23	—	2 4 25	2 4 49	0·5	2 10 25	—	—
17	251	„ 30	—	17 48 19	17 52 25	1·0	17 57 1	—	—
18	—	Feb. 5	—	14 8 29	14 18 31	3·0	14 52 46	—	—
19	—	„ 5	—	16 41 5	16 48 51	2·0	16 55 34	—	—
20	—	„ 6	—	18 32 36	18 37 35	1·5	18 43 47	—	—
21	—	„ 6	—	20 42 15	20 46 4	1·5	20 54 32	—	—
22	—	„ 7	—	4 53 29	5 3 31	1·0	5 18 0	—	—
23	—	„ 7	—	20 28 27	20 33 7	2·5	20 49 27	—	Time slightly uncertain.
24	—	„ 8	—	0 50 1	0 54 31	1·0	1 0 4	—	—
25	—	„ 10	—	13 36 28	13 43 21	1·0	13 46 54	—	?

Notes.—After November 12 the period of the oscillation may be taken as 16 secs. Before that time it was less, but the exact period is very uncertain and was variable.

7. *Bombay: Colaba. Abstract from Report by* N. A. F. Moos, Esq., *Director of the Government Observatory.*

The instrument at the Bombay Government Observatory is installed in a small isolated building 10 feet square and 14 feet up to the eaves, which was formerly used for electrostatical observations. It has a gable roof, and is well ventilated on all sides. On the west side, at a distance of 40 feet, is a carriage drive leading to the Directors' quarters, and at a distance of 70 feet in the same direction, and parallel to the drive, is the main road outside the Observatory compound. On the east side, there is to a distance of 60 feet open ground as far as the thermograph shed, beyond which an open tract continues to the sea. On the north side there is a small well and open ground for 120 feet, where the observers' quarters are situated. Probably in consequence of a copious ventilation, no troubles have been experienced with the so-called earth tremors.

The pier is oriented N.S. and E.W., and located in the centre of the room. Its foundation was dug $5\frac{1}{2}$ feet below the flooring of the room, which is $1\frac{1}{2}$ feet above the ground. At this depth a huge boulder was struck, upon which was laid a bed of concrete 5×5 feet square and 2 feet deep. Over this a mass of rubble masonry 4×4 feet and $1\frac{1}{2}$ feet thick was built, and upon this a brick pillar $1\frac{1}{2}$ feet square and $5\frac{1}{2}$ feet high. On the top of this there is 1 inch of cement and a $\frac{1}{2}$-inch marble slab. On the north side to carry the clock box there is a heavy table 3 feet 9 inches square. The Observatory stands on somewhat elevated ground formed of basaltic traps, with their inter-trappean beds of hard red earth.

The records commence on September 8, 1898. The period of the boom has been kept at 18 secs., the sensibility being such that a deflection of 1 mm. corresponds to a tilt of 0·38″. No difficulties have been experienced in the working of the instrument beyond an occasional slight falling of the boom, due, perhaps, to a stretching of the silk thread at the upper end of the tie. The sensibility is determined weekly by observation and by deflections whilst the film is in the box, thus preserving a photographic record of the same. By stretching a fine wire across the slit in the clock box an accurate zero line is obtained.

Regular tremors and pulsations are absolutely absent.

The list on the next page only contains records which correspond with records obtained in the Isle of Wight. The complete Bombay Catalogue, commencing on September 8, 1898, to June 2, 1899, contains 2,021 entries. These refer to shocks which were local, and do not appear to have reached Europe, curious irregular sinuosities varying in period from a few minutes to an hour, sudden displacements or dislocations in the position of the boom, and numerous thickenings of the normal record. The latter, in some instances, may be the result of slight earth tremors, but where they are continuous over several hours and have an irregular, bead-like appearance, it is likely that they are due to air currents. Movements due to such causes are most frequent at night. The cause of the sinuosities and sudden displacements is at present unknown.

In an official report on the condition and proceedings of the Colaba Observatory, dated April 29, 1899, in reference to Seismology, Mr. Moos says, that the seismograph appears to give every satisfaction. At first tremors were absolutely absent, but they appeared in the middle of November, and subsequently caused great trouble. To arrive at the causes producing these tremors, Mr. Moos has instituted a series of experiments, and he has found it possible to suppress their existence by regulating the temperature and draught in the room by four small kerosine lamps kept burning between 8 p.m. and 9 a.m. The introduction of these lamps also results in giving the zero of the boom a fluctuation almost analogous to that observed in the diurnal wave.

Excerpt from the Bombay Register.

No.	Shide No.	Date	Commencement	Maximum	End	Remarks
				1898.		
			H. M. S.	H. M. S.	H. M. S.	
1	232	Sept. 13	18 53 28	--	18 56 10	Thickening of line.
2	233	" 22	12 40 45	12 49 8	12 54 24	Eleven bead-like movements.
3	234	" 25	12 18 37	12 20 36	12 31 53	Small disturbance.
4	235	Oct. 11	17 2 36	17 36 42	17 48 57	Earthquake. Amp. 0″·78.
5	238	" 15	3 46 41	3 47 24	4 8 49	Earthquake. Amp. 2″·03. Felt over Northern Bombay.
6	239	Nov. 17	13 14 19	13 34 0	14 39 10	Earthquake. Amp. 3″·80.
7	240	" 30	21 4 35	—	(Dec. 1) 3 49 25	Real movement masked by feeble tremors. Also Dec. 1 from 12h. 43m. 17s.
8	241 ?	Dec. 3	2 49 58	—	—	Dislocation.
9	244	" 4	20 28 5	--	(5th) 3 15 58	Movement masked by tremors.
				1899.		
10	245	Jan. 6	19 13 40	—	(7th) 4 43 34	" "
11	246	" 11	19 23 44	—	(12th) 4 11 36	" "
12	247	" 12	9 33 24	--	—	Dislocation with vibration.
13	248	" 13	19 41 37	—	(14th) 4 21 2	Movement masked by tremors.
14	249	" 22	9 15 47	—	—	Dislocation W. with vibration.
15	250	" 25	12 57 59	—	—	" "
16	251	" 30	17 50 16	17 58 34	18 15 28	Small disturbance.
17	252	" 31	12 23 20	—	—	Dislocation E. with vibration.
18	253	" 31	17 16 21	—	—	Thickening of line.
19	256	Feb. 27	10 42 20	—	—	Dislocation W. with vibration.
20	257	" 27	14 40 50	—	—	" "
21	259	" 28	20 9 23	—	—	" "
22	263	Mar. 7	0 3 47	--	1 31 13	Tremors mask the real record.
23	264	" 12	10 31 41	--	—	Thickening of line.
24	268	" 23	11 42 30	11 47 46	12 22 4	Small disturbance.

8. *India: Calcutta, Alipore Observatory.*
G. W. KÜCHLER, *Assistant Meteorological Reporter.*

At the above Observatory, in consequence of an indifferent foundation, dampness, the presence of insects, and from other causes, great difficulties have been met with in working the instrument. These to some extent have been overcome, and it is expected that better results will be obtained.

The Calcutta Register.

No.	Shide No.	Date		Time H.	M.	S.	Remarks	H.	M.	S.	
				1899.							
1	—	Jan.	18	16	12	2	End	16	50	10	
2	—	„	25	21	57	3	„	22	32	14	
3		Feb.	18	3	15	52	„	3	29	45	Amp. less than 2 mm.
4	—	„	23	3	3	33	„	3	21	2	„ 2 mm.
5	264	Mar.	12	8	51	20	„	10	41	3	
6	266	„	19	12	36	18	„	15	8	58	„ 2 mm.
7	—	„	21	9	12	24				—	
8	267	„	21	14	43	6	„	15	29	53	
9	269	„	23	13	12	38	„	14	22	53	„ 4 mm.
10	—	„	26	11	53	47	(about)				

The above have been extracted from a selected list of disturbances commencing January 15, 1899.

9. *Java: Batavia. Magneetisch en Meteorologisch Observatorium. Director,* Dr. J. P. van der Stock.

Observations with the Milne horizontal pendulum commenced on June 1, 1898. The period or time of double swing is kept at an average of 17 seconds. It is installed in the magnetometer room. The observatory is situated on a plain of alluvium. Difficulties arising from 'air tremors' have not been reported from this station.

The Batavia Register.

No.	Shide No.	Date		Commencement: Small Pulsations H. M.	Commencement: Maximum H. M.	Duration H. M.
				1898.		
1	—	June	4	15 3·7	15 3·9	0 13·9
2	—	„	18	8 0·5	8 0·7	0 3·5
3	214	„	22	6 42·3	6 44·8	0 12·3
4	219	July	12	11 38·1	11 38·4	0 6·5
5	—	„	17	11 32·8	11 37·5	0 3·2
6	—	Aug	1	16 6·8	—	0 3·8
7	230	„	31	20 1·3	20 21·7	1 14·4
8	—	Sept.	1	9 4·3	9 10·4	0 31·9
9	—	„	2	18 47·8	18 55·8	0 17·0
10	—	„	3	8 27·3	8 28·2	0 4·4
11	232	„	13	18 2·1	18 10·7	0 57·7
12	233	„	22	12 27·3	12 29·1	0 58·9
13	—	„	30	12 4·0	12 5·2	0 5·8
14	—	Oct.	2	14 44·5	14 53·0	0 23·4
15	—	„	3	0 9·5	—	Doubtful
16	—	„	7	20 27·7	20 36·2	0 21·8
17	235	„	11	16 49·7	—	1 10·5
18	238	„	15	4 11·7	4 21·2	0 13·0
19	—	„	15	10 54·5	10 55·9	0 2·3
20	—	„	18	19 25·0	19 29·0	0 39·3

THE BATAVIA REGISTER—*continued.*

No.	Shide No.	Date	Commencement: Small Pulsations	Commencement: Maximum	Duration
			H. M.	H. M.	H. M.
21		Oct. 22	0 9·3	0 19·6	0 26·6
22		Nov. 2	11 28·8	11 29·3	1 0 1
23	—	„ 5	11 59·5	—	0 0·8
24	—	„ 13	15 33·4	15 33·6	0 10·2
25	239	„ 17	13 12·6	13 13·0	0 37·6
26	—	„ 28	7 45·2	7 46·8	0 9·3
27	—	„ 29	22 34·0	22 36·4	0 9·4
28	—	Dec. 2	12 21·6	12 27·2	0 13·4
29	243	„ 3	16 59·9	17 0·6	0 2·0
30	—	„ 4	7 18·0	7 25·4	0 9·0
31	—	„ 6	7 43·8	7 44·2	0 28·9
32	—	„ 6	10 28·6	10 28·8	0 2·1
33	—	„ 6	13 31·5	13 34·8	0 22·2
34	—	„ 10	3 0·7	3 1·7	0 6·0
35	—	„ 11	2 11·1	2 13·5	0 7·6
36	—	„ 17	1 51·1	1 51·2	0 0·6
37	—	„ 21	3 52·3	3 53·5	0 2·4
38	—	„ 22	9 2·9	9 4·9	0 29·8
39	—	„ 23	21 56·0	21 56·2	0 0·7
40	—	„ 29	2 44·6	2 44·9	0 1·1
41	—	„ 31	9 16·0	9 22·5	0 11·7
		1899.			
42	247	Jan. 12	8 4·3	8 8·8	0 19·0
43	264	Mar. 12	—	10 8·2	0 25·0

Nos. 15 and 19 were also recorded by Ewing's Bracket Seismograph. Nos. 1, 4, 5, 6, 12, 15 and 19 were also felt at different places in West Java and Sumatra. Earthquakes felt on the Eastern part of the Archipelago (Moluccas) are not yet regularly recorded.

10. *Mauritius: Royal Alfred Observatory. Director*, T. F. CLAXTON, *F.R.A.S.*

The Observatory, in lat. 20° 5′ 39″ S., and long. 3h. 50m. 12·6s. E., is situated on a plateau about four miles from the north-west coast, and 180 feet above mean sea level. The soil around the Observatory varies from 3 to 14 feet in depth, below which is solid basalt. Extending for about half a mile to the west is a forest, thickly wooded with thin acacia trees, and to the east are principally fields of sugar cane.

The instrument is mounted with its boom pointing north, in a small hut containing two brick pillars, formerly used for the electrometer. The building is 8 feet long by 5 feet wide, and 9 feet high. The roof and walls are of wood, covered on the outside with painted canvas, while the floor is of concrete. I am not at present in a position to state whether the foundation of the piers is on the solid rock, though it certainly is not more than a few feet above.

Observations were commenced in the middle of September, 1898. All the seismograms have been tabulated and subjected to analysis, and the results will be published in due time; they show principally five things :—

(*a*) That there is a large diurnal variation in level (probably larger

N 2

than at any other observing station) with a marked bi-diurnal effect, as shown by Bessel's interpolation formula, which for the months of October 1898, to March 1899, is

$$2''\cdot61 \sin(\theta + 295^\circ\cdot47') + 0''\cdot73 \sin(2\theta + 331^\circ\cdot57') + 0''\cdot30 \sin(3\theta + 272^\circ\cdot57'),$$

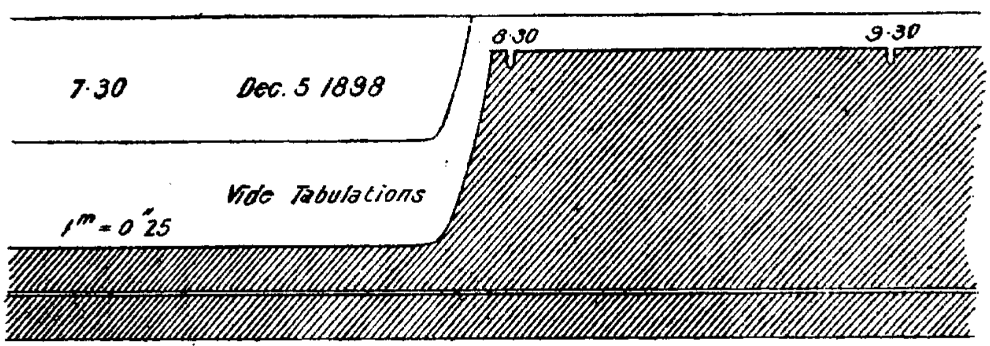
indicating a possible connection with the atmospheric pressure; the formula for the diurnal variation of which is

$$0\cdot0108 \text{ in. } \sin(\theta + 49^\circ 32') + 0\cdot0285 \text{ in. } \sin(2\theta + 163^\circ 2') + 0\cdot0020 \text{ in. } \sin(3\theta + 26^\circ 4').$$

(*b*) That rapid changes in the vertical occasionally occur on a large scale, notably on 1898 December 5, 6 and 7, and 1899 January 7, and February 10 and 11.

On December 5 (see diagram) after a dry period for a few days, a very heavy cloud formed at about 11 A.M.; its eastern edge was clearly defined, and extended for about a mile to the Eastward; shortly after noon very heavy rain began to fall at and to the west of the Observatory. The effect on the seismograph is seen in the accompanying diagram.

FIG. 1.



(*c*) That air tremors occur every night, in spite of every precaution to ensure copious ventilation, and the prevention of convection currents. They begin at sunset with small movements, which rapidly become larger, but, although of variable amplitude during the night, do not show a marked maximum: they finally die away at sunrise. As a general rule the tremors are greatest when the fall of temperature during the night is greatest; but this is not always the case.

(*d*) That on almost every day the westerly movement of the boom exceeds the easterly, indicating a gradual sinking of the land west of the instrument.

We must conclude that this movement is only local, for if the whole island tilted in this way as a rigid body, land would appear on the east coast, which was previously submerged, and *vice versâ* on the west coast, and up to now I have been unable to obtain evidence that such a thing has taken place.

(*e*) That the earthquake effects are comparatively small, as will be seen from an inspection of the accompanying list. This makes us question whether it is possible for the ocean to act as a damper to earthquake shocks.

When records are forthcoming from Honolulu we may learn more of this subject.

Beside the above five phenomena, there is another interesting point to be considered : the variation in the scale value of the instrument. As the boom points to the north, an increased sensibility means that the boom pillar has tilted towards the south, and *vice versâ.*

In the following table will be found the smoothed scale values for every four days from 1898, October, to 1899, January. (A bar represents an adjustment.)

Value of 1 *Mill.*

Day	October	November	December	January
4	33	38	25	32
8	32	50	42	41
12	31	45	38	50
16	30	36	38	58
20	25	28	32	33
24	18	26	28	33
28	54	25	24	33
32	46	25	21	33

If the above figures are plotted down on a curve, after allowing for the alterations for adjustment, it will be seen that the boom tilted towards the south till November 25 ; was then practically stationary till the middle of December, after which the tilting continued towards the south till the end of the month, when a northerly tilt set in, lasting till January 16, after which the boom was stationary.

Mauritius Register.

No.	Shide No.	Date	Commencement	Maximum	Remarks
			1898.		
			H. M. S.	H. M. S.	A.
1	—	Sept. 19	—	11 1 39	2''·4. Commencement 1h. earlier ?
2	233	„ 22	—	13 50 25	0''·45.
3	238	Oct. 15	4 6 12	4 10 0	0''·15. D 22m.
4	239	Nov. 17	13 45 23	14 2 0	0''·66. D 40m.
5	240?	Dec. 1	—	0 58 43	Earthquake ?
6	244?	„ 4	7 30 0	7 52 0	0''·12. D 45m.
7	—	„ 11	About 7 0 30	7 36 5	0''·38. D 1h. 22m. (See Register for Toronto, Victoria, Nicolaiew.)
			1899.		
8	250	Jan. 25	—	1 15 45 and	0''·99.
9	—	„ „	—	1 19 0	From 6.30 to noon, about 20 small disturbances. One about 9h. looks seismic.
10	263	March 6	—	23 20 0 to March 7 1 35 0	Slight thickenings of the line.
11	264	„ 12	—	8 20 0 to 10 50 0	Slight thickenings of the line.

11. *Cape of Good Hope: Royal Observatory. Director*, DAVID GILL, Esq., *F.R.S.*

The instrument was mounted on a concrete pier based on a rock foundation, and was experimentally started on June 20, 1899.

At first difficulties were experienced in attaining the necessary amount of sensitiveness. There appeared to be a large amount of friction which prevented the boom swinging freely. This, however, was remedied by a readjustment of the balance weights, and the instrument has been recording with occasional interruption since July 11.

The principal events so far registered are as below, the times being referred to Greenwich mean civil time.

The Cape Register.

1899.

1. July 14—

	H.	M.
Preliminary tremors	13	47·2
Commencement of decided motion . .	14	17·2
End of decided motion	15	32·6

Maximum amplitude, 3 mm.

Also recorded at Shide.

2. July 18—

	H.	M.
Preliminary tremors	21	14·6
Commencement of decided motion . .	21	18·0

Maximum amplitude, 3 mm.

Times of maxima, 21h. 23·2m., 21h. 34·4m.

3. July 20—

Slight tremors from about 0h. to 7h., commencement and end not well marked. More violent disturbance for about 10m.; maximum displacement $2\frac{1}{2}$ mm. at 3h. 40m.

4. July 20—

Disturbance commenced at 19h. 17m. The motion subsided from 19h. 26·8m. but restarted at 19h. 44·2m., and finally ceased at 19h. 59·5m.

5. July 27—

Disturbance commenced without preliminary tremors at 15h. 4·7m. Maximum displacement about $2\frac{1}{2}$m. after commencement. Greatest amplitude of swing, 9mm. Total duration, 45m., with calm interval of 10m.

6. July 31—Violent disturbance.

	H.	M.
Preliminary tremors	2	42·5
Commencement of decided motion . .	2	46·0
End of decided motion	3	39·8

The early part of this disturbance shows signs of a periodic character with a period declining from about 6m. to about 3m. The latter half is much more irregular in form. Well-marked maxima at 2h. 47m., 2h. 52m., 2h. 57m., 3h. 1m., 3h. 4m., and 3h. 25m. Displacements from centre amounting to 20 mm.

Several insignificant disturbances have also been recorded, besides those quoted above.

12. *Russia: Nicolaiew. The Observatory.* *Director,* Professor T. Kortazzi.

The Observatory of Nicolaiew (lat. 46° 58′·3, long. 2h. 7m. 9s.) is situated on a sandy hill with gently sloping sides at an elevation of 50m. above sea level. The streets of the town are at a distance of 150m., and the railway more than 1 km.

The von Rebeur Horizontal Pendulum, with its photographic registering apparatus, is placed in a cellar on a pillar isolated from the walls and the floor. The pillar is built of large blocks of very compact limestone, covered with tar to prevent the absorption of moisture. The annual change of temperature in the cellar does not exceed 4° R. Diurnal changes are not perceptible. A deviation of 1 mm. in the position of the light spot indicates a tilting of the pillar in the direction of the meridian of 0″·012. The recording surface moves at the rate of 22 mm. per hour.

The Nicolaiew Register.

The times for commencement, reinforcement, maximum, and weakening are indicated in Greenwich mean civil time:—½ amplitude = ½a in millimetres. P.T.'s = duration of preliminary tremors.

No.	Shide No.	Date	Commencement	Reinforcement	Maximum	½a	Weakening	Duration	P.T.'s	Remarks
			1898.							
			H. M.	H. M.	H. M.	MM.	H. M.	H. M.	M.	
1	—	Mar. 6	2 46	3 2	3 5	3·5	—	0 36	16	
2	—	„ 19	13 14	13 19	13 20	4	—	0 13	5	
3	—	„ 25	19 39	19 47						
				0 57·5	19 58	9	20 31	2 58	8	
4	—	„ 26	9 44		9 56	5·5	10 7	0 40	3	
5	—	„ 28	15 37	15 59·5	16 2	10·5	16 9	1 15	22·5	
					0 16	7·5	0 19			
6	182	„ 31	8 22	8 30	8 31	4	—	0 30	8	
7	185	Apr. 3	6 53	—	6 58	3	—	0 8	—	
8	189	„ 15	7 54	—	7 57	23	—	0 23	—	
9	—	„ 21	22 48	22 57·5	23 22	16	23 52	2 44	9·5	
10	—	„ 22	23 47	—	23 58	10	—	—	—	Pendulum inclined 8 mm. to the S.
11	193	„ 23	—	0 2	0 4·5	38	1 37	3 37	—	
12	195	„ 25	11 10·5	11 19	11 41	9	11 49	1 42	8·5	
13	—	„ 28	14 27	14 41·5	14 54	7·5	—	0 57	17·5	
14	196	„ 29	16 30	16 44·5						
				17 2	17 7	21	17 47	2 22	14·5	
15	199	May 7	6 4	6 11	6 38	25	7 12	2 33	7	
16	—	„ 19	9 15	9 39	9 42	4·5	—	0 55	—	
17	—	„ 26	2 2	—	2 22	4	—	1 20	—	
18	—	June 1	5 47	5 52	5 54	6	6 7	0 48	8	
19	210	„ 3	16 57	—	17 0	5	—	0 30	—	
20	—	„ 6	19 37	—	19 58	5	—	0 21	21	P.T.'s followed by a single shock at 19h. 58m.
21	213	„ 21	0 37	0 41·5	0 44	58	—	0 45	—	
22	214	„ 22	6 54	7 11	7 18	17	7 46			
				—	7 51	15	7 55	3 1	—	
23	—	„ 26	23 38	—	23 47	2	—	0 9	6	
24	215	„ 29	18 42	18 59	18 59	50 ?	—	—	12	
					19 17	40 ?	—	3 45		At 18h. 59m. to 19h. 7m. and 19h. 7m. to 19h. 22m. the traces are scarcely visible.
25	216	July 2	4 22	4 23·5	4 25	9	—	—	1·5	
26	—	„ 9	19 39	—	19 41	3	—	0 15	—	
27	—	„ 13	0 48	—	0 54	3	—	0 34	—	
28	221	„ 14	17 30	17 45	17 52	10	—	0 37	15	
29	—	„ 15	6 22	6 37	6 37	2·5	—	0 32	12	
30	225	Aug. 8	8 25	8 44	8 54	7	9 17	1 47	19	
31	—	„ 23	0 4·5	—	0 7	6	—	0 27	—	
32	—	„ 28	16 37·5	—	16 39	2·5	—	0 75	—	
33	230	„ 31	20 39	—	20 42	20	—	0 58	—	The photogram indistinct.
34	—	Sept. 1	9 11	9 20	9 39	22	10 10	2 29	9	
35	—	„ 2	19 16	—	19 29	7	19 47			
					20 0	6	—	1 6	—	
36	231	„ 3	15 32	15 59	16 2	7	—	1 20	—	
37	232	„ 13	18 14·5	—	18 34	10				
					19 12	13	—	1 38	—	

THE NICOLAIEW REGISTER—*continued.*

No.	Shide No.	Date	Commencement	Reinforcement	Maximum	½a	Weakening	Duration	P.T.'s	Remarks
			H. M.	H. M.	H. M.	MM.	H. M.	H. M.	M.	
38	233	Sept. 22	12 44	12 53	13 19	29	14 10	2 38	9	
39	234	„ 25	12 25	12 34	12 37	22	12 42	1 7	9	
40	—	„ 26	22 37·5	—	22 42	5	—	0 18	5	
41	—	„ 27	5 42	—	5 52	3	—	0 10	—	
42	—	„ 30	16 35	16 54	16 57	7	—	0 32	9	
43	—	Oct. 1	15 4	—	15 55	8	—	1 18	—	
44	—	„ 7	2 36	—	2 44	2·5	—	0 8	—	
45	—	„ 8	23 40·5	—	24 18	2	—	—	—	
46	235	„ 11	16 49·5	16 59·5	17 7	13	—	3 8	—	At 17h. 20m. the paper was changed. No details.
47	—	„ 12	22 14	—	22 17	3	—	—	—	
48	238	„ 15	3 28	4 5	4 10	7	—	1 14	37	
					0 14					
49	—	„ 18	19 56·5	20 5	20 9·5	6	—	0 25	8·5	
50	—	„ 22	0 13·5	0 28	0 32	4·5	0 39	—	9	
				0 40	1 0	19	1 27	2 25		
51	—	Nov. 2	11 50	12 14	12 18	6	—	0 50	—	
52	—	„ 9	18 47	—	18 48	3·5	—	0 5	—	
53	—	„ 14	7 29	7 39·5	7 42	3	—	0 35	10·5	
54	239	„ 17	13 3	13 12	13 37	18	13 52	1 31	9	
				0 17						
55	240	Dec. 1	12 42	—	12 54	15	—	1 0	—	
56	241?	„ 3	6 18	—	6 19	3	—	—	—	
57	—	„ 4	7 57	—	8 5	3	—	0 30	—	
58	—	„ 6	8 10	—	8 20	4	—	0 52	10	
59	—	„ 6	13 57·5	—	14 12	2·5	—	0 20	—	
60	—	„ 11	7 8	—	7 28	3·5	7 34	1 49	9	
					7 48	6	8 7			
61	—	„ 12	16 58	17 9·5	17 12	3·5		0 49	11·5	
62	—	„ 27	15 1	—	15 4	3		1 0	—	
				1899.						
63	—	Jan. 3	6 49	7 17	7 19	3	—	0 38	28?	
64	245	„ 6	19 23	—	19 46	6·5	19 57	1 39	10	
65	247?	„ 12	8 37	8 48	8 50	7	8 59	0 45	11	
66	248	„ 14	2 54	3 0	3 32	8	3 20	1 28	6	
67	249	„ 22	8 19	—	8 21	15	—	0 24	—	Earthquake in Greece (*Comptes rendus*, cxxviii. No. 8).
68	—	„ 23	2 13·5	2 19	2 22	4	2 38	1 8	5·5	
					0 42	4				
69	250	„ 24	23 57·5	0 1·5	0 12	30	—	2 55	4 or 10·5	
		„ 25		0 8	1 2					
70	251?	„ 30	17 59·5	—	18 25	3	—	0 37	—	
71	253?	„ 31	17 1·5	17 14	17 15	4	—	0 30	12·5	
72	—	Feb. 10	4 14·5	4 24	4 27	2	—	0 22	9·5	
73	—	„ 11	8 17	8 34	8 40	5·5	—	0 35	17	
74	256	„ 27	11 31·5	11 34	11 37	3·5	11 41	0 15	2·5	
75	—	„ 28	3 6·5	3 22	3 32	16	3 42	0 55	15·5	
76	—	Mar. 3	0 52	0 54·5	0 56	11·5	1 12	1 0	2·5	
77	262	„ 6	20 30	—	20 34	2·5	—	0 17	—	
78	263	„ 7	1 5	1 15	1 22	7	1 27			
				1 32	1 39	27	1 44	1 13	10	
79	264	„ 12	9 41·5	10 7	10 11	6	10 21			
				10 24	10 27	15		1 59	25	

13. *Potsdam.*

Professor Dr. Eschenhagen, of the Königliches Meteorologisch-Magnetisches Observatorium, in place of a list, kindly sent me photographic copies of the various seismographic records he had obtained between October 2, 1897 and Jan. 6, 1898. The observations were made by means of a conical pendulum, carrying a small mirror on a glass boom, 20 cm. in length, and held horizontally with a glass fibre.

Out of forty-three records, on dates between March 3, 1898, which corresponds to the commencement of this year's list for Shide, and January 6, 1899, there are twenty-nine of them corresponding to the Isle of Wight observations.

In the discussion of registers the times of these are given approximately, but can be obtained with greater accuracy if required.

14. *Excerpt from the Trieste Register.*

Observations corresponding to those in the Shide list, made by Herr EDUARD MAZELLE, *Astron.-Meteorol. Observatorium, Trieste. Rebeur-Ehlert Horizontal Pendulum. Photographic record.*

No.	Shide No.	Date	Commencement	Maximum	Range and Tilt	End	Remarks
				1899.			
			H. M.	H. M.	MM.	H. M.	
1	249	Jan. 22	8 15·85	8 21·57	84 (1″·47)	9 20·20	The time of commencement is that of the pendulum first set in motion. For complete records see *K. Akad. der Wissenschaften in Wien*, February 1899, and subsequent publications.
2	250	" 24 / " 25	23 58·38	0 48·86	33 (0″·5)	2 35·70	
3	255	Feb. 26	13 48·36	14 0·77	8		
4	257	" 27	15 28·28	15 40·55	4		
5	259	" 28	19 50·20	20 4·54	5		
6	260	" 28	22 42·83	23 14·52	2		
7	263	Mar. 7	1 6·89	1 42·88	10·5 (0″·3)	2 19·78	
8	264	" 12	9 53·10	10 7·37	13·16 (0″·34)	11 0 abt.	
9	266	" 19	1 24·29	—	2 (0″·06)	1 25·66	
10	267	" 21	14 46·63	15 22·25	5·5 (0″·16)		
11	268	" 23	10 42·80	11 5·12	5·8 (0″·13)	12 0 abt.	
12	269	" 23	14 29·96	14 47·69	3·5 (0″·08)	15 30·45	
13	270	" 25	14 53·48	14 55·31	1·5 (0″·32)	15 46·32	

15. *The Bidston Register.*

Darwin Bifilar Pendulum records, from the Liverpool Observatory, Bidston, Birkenhead, Cheshire. Director, W. E. PLUMMER, Esq.

No.	Shide No.	Date	Remarks
			1898.
1	—	Mar. 28	Moderate disturbance about 23h. 44m.
2	180	" 29	Continual slight disturbances throughout this period. The smallness of the time scale prevents exact identification.
3	—	April 3	Trace lost by clock failure.
4	196	" 29	Slight disturbance at about 17 hrs.
5	200	May 20	At 23h. 30m. Max. at 0h. 11m., and slight till 2h. 15m.
6	—	" 21	Commences at 15h., with max. at 17h. 30m. The Shide record for 22h. 50m. may have been recorded, but it is mixed up with an alteration to determine the time scale.
7	—	" 26	About 22h.
8	—	June 4	" 1h. 50m. slight. Trace off the scale.
9	—	July 21	Very slight.
10	—	" 29	10h. a disturbance.
11	225	Aug. 7	8h. to 8h. 30m.
12	—	" 19	Considerable disturbance.
13	228	" 21	16h. 50m. to 18h.
14	—	Nov. 7	12h. slight.
15	—	" 24	18h. "
16	—	Dec. 31	6h. 20m. to 9h.

THE BIDSTON REGISTER—*continued.*

No.	Shide No.	Date	Remarks
			1899.
17	—	Jan. 26	13h. to 14h. tremors.
18	—	Feb. 9	18h. 30m. ,,
19	254	,, 23	12h. 50m. slight.
20	—	—	Slight.
21	—	—	,,
22	—	Mar. 2	12h. to March 3 2h. Slight tremors, clearly marked.

16. *The Edinburgh Register.*

Observations at the Royal Observatory, Edinburgh, with a Darwin Bifilar Pendulum. Director, Dr. R. COPELAND.

No.	Shide No.	Date	Time	Remarks
				1898.
			H. M.	
1	174?	Mar. 5	17 11	Slight tilt to South.
2	179	,, 28	18 25	Very slight tilt to South.
3	180?	,, 29	15 41	,, ,, ,, North.
4	182?	,, 31	7 36·5	,, ,, ,, ,,
5	189	April 15	7 39	,, ,, oscillation, just perceptible.

Mr. Thomas Heath, who is in charge of the instrument, states that only one of the above coincidences is of an oscillatory character. A number of tilts and slight bends were recorded, but only one of these, on April 23, from 0h. 18m. to 0h. 36m., was oscillatory. The bends and tilts were most numerous in March, April, and May. From May 30 to November 11 there is practically not a trace of any kind of disturbance. From the latter date to the end of the year the number of tilts is small. A second pendulum was placed in position on May 14, and a couple of thermometers were installed in the pendulum chamber on May 31. They are covered by an earthenware dish. Between May 31 and March 20 the maximum temperature was, on September 21, 63°·2; the minimum was 51°·0 on February 26.

17. *Excerpt from the Rocca di Papa Register.*

Observations made at the R. Osservatorio Geodinamico di Rocca di Papa. By the Director, Dr. ADOLFO CANCANI.

Horizontal and other pendulums recording on smoked paper.

No.	Shide No.	Date	Commencement	Maximum	End
			1898.		
			H. M. S.	H. M. S.	H. M. S.
1	189	April 15	7 54 0	8 2 0	8 20 0
2	193	—	23 48 40	0 23 0	0 34 0
3	195	,, 25	11 40 0	11 42 0	11 45 0
4	196	,, 29	16 40 0	16 43 0	17 18 0
5	199	May 7	6 5 30	6 14 0	6 53 0
6	213	June 21	0 53 20	0 58 0	1 8 0
7	214	,, 22	6 45 2	6 45 18	6 55 0

THE ROCCA DI PAPA REGISTER—*continued.*

No.	Shide No.	Date	Commencement	Maximum	End
			H. M. S.	H. M. S.	H. M. S.
8	215	June 29	18 48 42	18 59 about	21 0 0
9	216	July 2	4 19 0	4 21 0	4 48 0
10	230	Aug. 31	20 3 40	20 31 0	21 30 0
11	232	Sept. 13	18 11 38	18 11 55	18 13 30
12	233	„ 22	12 58 0	13 33 about	14 0 0 about
13	235	Oct. 11	16 50 35	17 32 0	18 0 0 „
14	239	Nov. 17	13 4 40	13 46 30	14 10 0
		1899.			
15	245	Jan. 6	19 49 0	19 52 30	20 0 0 about
16	249	„ 22	8 16 10	8 20 40	8 27 0
17	250	„ 25	0 0 0	—	0 50 0 „
18	263	March 7	1 13 0	1 52 0	2 15 0

None of the very small disturbances on the supplementary list were recorded.

18. *Excerpt from the Casamicciola Register.*

Records received from Dr. GIULIO GRABLOVITZ, *Director R. Osservatorio Geodinamico di Casamicciola, Ischia.*

Records from horizontal pendulums recording on smoked paper are marked. H.P.; and those from the Vasca Sismica, V.S.

No	Shide No.	Date	Commencement	Maximum	End	Remarks
			1898.			
			H. M. S.	H. M. S.	H. M. S.	
1	189	April 15	8 0 0	—	8 10 0	H.P.
2	193	„ 22	23 30 0	—	0 50 0	H.P. The V.S. commenced at 23h. 48m. 46s.
3	—	„ 24	—	0 25 0 and 0 33 0	—	H.P.
4	196	„ 29	16 58 0	—	17 8 0	
5	199	May 7	6 33 0	—	6 38 0	H.P. V.S. from 6h. 24m. 35s. to 6h. 26m. 9s.
6	214	June 22	6 51 48	—	—	By several instruments. Duration several mins. Origin, Greece.
7	— 215	„ 29	12 20 0 and 18 50 0	—	—	H.P. feeble oscillations. V.S. from 18h. 47m. 47s.
8	216	July 2	4 19 12	—	4 30 0	Various instruments. Strong. Origin, Dalmatia.
9	223	„ 21	11 31 0	—	11 41 0	H.P.
10	230	Aug. 31	20 3 45	20 30 0	21 0 0	
11	232	Sept. 13	18 12 0	—	20 0 0	
12	233	„ 22	12 54 0	—	14 4 0	
13	235	Oct. 11	16 50 34	—	18 14 0	
14	239	Nov. 17	13 30 0	—	14 0 0	
			1899.			
15	249	Jan. 22	8 14 37			Origin, Greece.
16	263	Mar. 7	1 30 0			

19. *Excerpt from the Catania Register.*

Observations made at the R. Osservatorio di Catania e dell' Etna by the Director, Dr. A. Ricco.

The records are from the 'grande seismografo,' a pendulum 25m. long, carrying 300 kilos.

No.	Shide No.	Date		Commencement	Maximum	Duration	Amp.	Remarks
				1898.				
				H. M. S.	H. M. S.	H. M. S.	MM.	
1	—	Mar.	29	2 13 45	2 15 30	1 6 33	1	
2	—	Apr.	3	—	—	—	—	Slight perturbations especially in the morning occasioned by a strong W. wind.
3	—	,,	4	—	—	—	—	As above, but the perturbations were stronger.
4	193	,,	22	23 48 58	0 33 47 0 34 29	0 56 25	1	
—		,,	25	—	—	—	—	Perturbations due to the movements of the sea for 24 hours.
5	196	,,	29	16 33 40	17 1 4	2 26 25	0·5	
6	199	May	7	6 1 40	6 45 33 7 56 18	1 11 56	0·37	
7	—	,,	20	—	—	—	—	Perturbations due to the sea.
8	201	,,	22	16 33 39	—	0 0 34	—	Local earthquake S.W. of Etna.
9	214	June	22	6 51 48	6 52 56	2 3 20	1·15	
10	215	,,	29	18 49 8	19 1 5	2 4 14	1·5	
11	216	July	2	4 19 52	4 23 37	0 26 56	3·8	
12	—	,,	12	—	—	—	—	Perturbations due to the sea.
13	220	,,	14	0 30 26	0 30 26	0 10 30	0·25	
14	—	,,	14	—	—	—	—	Perturbations due to the sea.
15	—	,,	20	—	—	—	—	Small perturbations in the morning.
16	223	,,	21	11 28 41	11 33 31	0 14 35	0·75	
17	—	Aug.	8	—	—	—	—	Small perturbations all day.
18	—	,,	22	—	—	—	—	Small perturbations in the morning.

THE CATANIA REGISTER—*continued.*

No.	Shide No.	Date		Commencement	Maximum	Duration	Amp.	Remarks
				H. M. S.	H. M. S.	H. M. S.	MM.	
19	230	Aug.	31	20 4 3	20 12 33	1 34 51	0·8	
20	—	Sept.	3	6 19 0	—	—	—	Of doubtful character.
21	232	,,	13	18 10 31	18 11 27	2 34 30	0·5	
22	233	,,	22	12 40 32	Uncertain	2 7 46		
23	235	Oct.	11	17 3 22	17 38 42 } 17 39 56 }	1 26 43	0·5	
24		,,	15	—	—	—	—	Movements due to the sea.
25	239	Nov.	17	11 59 33	Uncertain	1 57 47		
26	240	Dec.	1	12 38 11	12 49 51	0 48 59	0·17	
				1899.				
27	245	Jan.	6	19 46 11	Uncertain	0 28 8		
28	249	,,	22	8 14 11	8 19 48	0 22 37	2·5	
29	250	,,	25	0 1 43	Uncertain	1 19 51		
30	—	,,	26	—	—	—	—	Movements due to the sea.
31	263	Mar.	7	1 18 14	1 19 23	0 4 42	0·25	
32	—	,,	12	—	—	—	—	Movements due to the sea.
33	267	,,	21	14 46 24	14 57 30	0 22 24	0·5	
34	268	,,	23	10 34 15	11 9 48	1 15 45	0·25	
35	269	,,	23	14 18 1	14 54 45	0 59 25	0·15	

20. *Seismometrical Observation at Tokio.*

Catalogue of Earthquakes recorded by a Gray-Milne Seismograph at the Central Meteorological Observatory, Tokio, January 27, 1898, *to January* 29, 1899. (*Continuation of Catalogue commencing in the British Association Report,* 1886.)

No.	Date	Local time of Occurrence. 9 hrs. in advance of Greenwich	Duration	Horizontal Motion					Vertical Motion	
				Direction	Maximum Range		Maximum Velocity	Maximum Acceleration	Maximum Range	
					Period	Amplitude	mm. secs.	mm. secs.	Period	Amplitude
					1898.					
		H. M. S.	M. S.		SECS.	MM.			SECS.	MM.
1,982	Jan. 27	10 43 27 P.M.	—	—	—	slight	—	—	—	—
1,983	Feb. 10	0 15 2 P.M.	—	—	—	,,	—	—	—	—
1,984	,, 13	11 52 47 A.M.	—	—	—	,,	—	—	—	—
1,985	,, 13	11 58 36 P.M.	2 40	S.S.E., N.N.W.	0·7	1·4	6·3	56·4	0·5	0·5
1,986	,, 14	6 5 48 A.M.	—	—	—	slight	—	—	—	—
1,987	,, 21	6 49 6 A.M.	—	—	—	,,	—	—	—	—
1,988	,, 23	5 57 10 P.M.	—	—	—	,,	—	—	—	—
1,989	,, 26	5 14 47 P.M.	—	—	—	,,	—	—	—	—
1,990	,, 28	3 51 31 A.M.	—	—	—	,,	—	—	—	—
1,991	Mar. 3	11 6 10 P.M.	—	—	—	,,	—	—	—	—
1,992	,, 4	9 5 20 A.M.	—	—	—	,,	—	—	—	—
1,993	,, 5	1 4 21 P.M.	—	—	—	,,	—	—	—	—
1,994	,, 5	5 41 47 P.M.	—	—	—	,,	—	—	—	—

CATALOGUE OF EARTHQUAKES RECORDED AT TOKIO—*continued*

No.	Date	Local time of Occurrence, 9 hrs. in advance of Greenwich	Duration	Horizontal Motion: Direction	Horizontal Motion: Maximum Range: Period	Horizontal Motion: Maximum Range: Amplitude	Horizontal Motion: Maximum Velocity, mm. secs.	Horizontal Motion: Maximum Acceleration, mm. secs.	Vertical Motion: Maximum Range: Period	Vertical Motion: Maximum Range: Amplitude
		H. M. S.	M. S.		SECS.	MM.			SECS.	MM.
1,995	Mar. 5	11 41 8 P.M.	—	—	—	slight	—	—	—	—
1,996	,, 9	4 45 9 A.M.	—	—	—	,,	—	—	—	—
1,997	,, 9	6 19 25 A.M.	—	—	—	,,	—	—	—	—
1,998	,, 9	10 2 24 A.M.	—	—	—	,,	—	—	—	—
1,999	,, 15	1 0 21 P.M.	—	—	—	,,	—	—	—	—
2,000	,, 16	10 13 4 P.M.	—	—	—	,,	—	—	—	—
2,001	,, 17	3 21 12 A.M.	—	—	—	,,	—	—	—	—
2,002	,, 17	3 26 54 A.M.	—	—	—	,,	—	—	—	—
2,003	,, 22	10 31 38 P.M.	—	—	—	,,	—	—	—	—
2,004	,, 24	10 29 7 P.M.	—	—	—	,,	—	—	—	—
2,005	,, 27	3 24 7 A.M.	1 6	N.N.W., S.S.E.	0·3	0·7	7·3	153·5	—	slight
2,006	,, 27	11 25 8 P.M.	—	—	—	slight	—	—	—	—
2,007	Apr. 3	6 10 6 A.M.	2 30	N.W., S.E.	0·5	1·5	9·4	118·4	0·3	0·3
2,008	,, 4	8 27 5 P.M.	—	—	—	slight	—	—	—	—
2,009	,, 4	10 42 32 P.M.	—	—	—	,,	—	—	—	—
2,010	,, 6	1 27 15 A.M.	—	—	—	,,	—	—	—	—
2,011	,, 9	3 40 5 A.M.	—	—	—	,,	—	—	—	—
2,012	,, 11	9 56 32 A.M.	—	—	—	,,	—	—	—	—
2,013	,, 12	5 41 29 A.M.	—	—	—	,,	—	—	—	—
2,014	,, 14	3 30 23 P.M.	—	—	—	,,	—	—	—	—
2,015	,, 18	8 57 11 P.M.	—	—	—	,,	—	—	—	—
2,016	,, 20	2 4 24 A.M.	—	—	—	,,	—	—	—	—
2,017	,, 21	8 4 7 P.M.	—	—	—	,,	—	—	—	—
2,018	,, 23	0 55 45 A.M.	—	—	—	,,	—	—	—	—
2,019	,, 23	8 36 49 A.M.	12 0	S., N.	0·9	0·8	2·8	15·6	—	—
2,020	,, 26	7 07 51 P.M.	—	—	—	,,	—	—	—	—
2,021	,, 29	0 23 8 A.M.	—	—	—	,,	—	—	—	—
2,022	,, 29	9 38 21 P.M.	—	—	—	,,	—	—	—	—
2,023	,, 30	3 17 0 A.M.	—	—	—	,,	—	—	—	—
2,024	May 6	7 22 59 A.M.	—	—	—	,,	—	—	—	—
2,025	,, 6	7 48 33 A.M.	—	—	—	,,	—	—	—	—
2,026	,, 7	5 38 0 P.M.	—	—	—	,,	—	—	—	—
2,027	,, 9	2 49 6 A.M.	—	—	—	,,	—	—	—	—
2,028	,, 9	6 21 40 P.M.	—	—	—	,,	—	—	—	—
2,029	,, 10	8 26 43 A.M.	—	—	—	,,	—	—	—	—
2,030	,, 14	8 31 0 A.M.	—	—	—	,,	—	—	—	—
2,031	,, 19	11 55 55 P.M.	—	—	—	,,	—	—	—	—
2,032	,, 22	1 14 48 A.M.	—	—	—	,,	—	—	—	—
2,033	,, 23	1 51 43 A.M.	—	—	—	,,	—	—	—	—
2,034	,, 23	11 1 8 P.M.	—	—	—	,,	—	—	—	—
2,035	,, 26	3 0 32 A.M.	2 10	N.W., S.E.	0·5	1·8	11·3	182·1	0·2	0·2
2,036	,, 26	3 37 4 A.M.	—	—	—	slight	—	—	—	—
2,037	,, 26	4 55 33 A.M.	—	—	—	,,	—	—	—	—
2,038	,, 26	2 28 2 A.M.	—	—	—	,,	—	—	—	—
2,039	,, 31	1 9 0 A.M.	—	—	—	,,	—	—	—	—
2,040	June 1	4 20 12 P.M.	—	—	—	,,	—	—	—	—
2,041	,, 6	10 39 51 P.M.	—	—	—	,,	—	—	—	—
2,042	,, 8	9 13 30 A.M.	—	—	—	,,	—	—	—	—
2,043	,, 9	11 40 23 A.M.	—	—	—	,,	—	—	—	—
2,044	,, 12	2 31 18 A.M.	—	—	—	,,	—	—	—	—
2,045	,, 12	10 25 52 A.M.	—	—	—	,,	—	—	—	—
2,046	,, 12	3 24 54 P.M.	—	—	—	,,	—	—	—	—
2,047	,, 13	3 43 15 P.M.	—	—	—	,,	—	—	—	—
2,048	,, 15	1 15 8 P.M.	—	—	—	,,	—	—	—	—
2,049	,, 21	10 22 19 A.M.	—	—	—	,,	—	—	—	—
2,050	,, 24	3 47 47 A.M.	—	—	—	,,	—	—	—	—
2,051	,, 30	0 12 6 P.M.	—	—	—	,,	—	—	—	—
2,052	,, 30	10 6 19 P.M.	1 10	N.E., S.W.	0·1	0·3	9·4	592·2	—	—
2,053	July 5	6 56 57 P.M.	—	—	—	slight	—	—	—	—
2,054	,, 7	6 35 49 P.M.	—	—	—	,,	—	—	—	—
2,055	,, 12	0 35 7 A.M.	—	—	—	,,	—	—	—	—
2,056	,, 12	5 40 39 P.M.	—	—	—	,,	—	—	—	—
2,057	,, 12	10 55 35 P.M.	1 50	S.W., N.E.	0·3	0·8	8·4	175·5	0·2	0·2
2,058	,, 13	1 19 35 A.M.	—	—	—	slight	—	—	—	—
2,059	,, 15	8 9 45 P.M.	—	—	—	,,	—	—	—	—
2,060	,, 15	7 8 50 P.M.	—	—	—	,,	—	—	—	—
2,061	,, 15	5 10 41 A.M.	—	—	—	,,	—	—	—	—
2,062	,, 18	3 20 26 P.M.	—	—	—	,,	—	—	—	—

CATALOGUE OF EARTHQUAKES RECORDED AT TOKIO—*continued.*

No.	Date	Local time of Occurrence. 9 hrs. in advance of Greenwich	Duration	Horizontal Motion: Direction	Horizontal Motion: Maximum Range: Period	Horizontal Motion: Maximum Range: Amplitude	Horizontal Motion: Maximum Velocity mm. secs.	Horizontal Motion: Maximum Acceleration mm. secs.	Vertical Motion: Maximum Range: Period	Vertical Motion: Maximum Range: Amplitude
		H. M. S.	M. S.		SECS.	MM.			SECS.	MM.
2,063	July 19	2 49 35 A.M.	—	—	—	slight	—	—	—	—
2,064	,, 20	6 41 54 P.M.	—	—	—	,,	—	—	—	—
2,065	,, 22	7 17 6 A.M.	—	—	—	,,	—	—	—	—
2,066	,, 25	6 20 11 A.M.	2 10	S.S.W., N.N.E.	0·3	0·4	4·2	87·7	—	—
2,067	,, 25	0 17 13 P.M.	1 20	S.E., N.W.	0·4	1·0	7·9	123·4	0·2	0·3
2,068	,, 27	2 35 21 A.M.	—	—	—	slight	—	—	—	—
2,069	Aug. 1	1 24 18 P.M.	—	—	—	,,	—	—	—	—
2,070	,, 4	8 48 45 A.M.	—	—	—	,,	—	—	—	—
2,071	,, 7	11 3 45 P.M.	—	—	—	,,	—	—	—	—
2,072	,, 11	5 40 47 P.M.	1 20	N.E., S.W.	0·3	1·2	12·6	263·2	0·1	0·2
2,073	,, 17	4 16 23 P.M.	—	—	—	slight	—	—	—	—
2,074	,, 21	0 9 39 A.M.	—	—	—	,,	—	—	—	—
2,075	,, 21	1 29 51 A.M.	—	—	—	,,	—	—	—	—
2,076	,, 22	11 40 33 P.M.	—	—	—	,,	—	—	—	—
2,077	,, 23	8 5 20 A.M.	—	—	—	,,	—	—	—	—
2,078	,, 23	11 47 59 A.M.	—	—	—	,,	—	—	—	—
2,079	,, 27	4 38 14 A.M.	—	—	—	,,	—	—	—	—
2,080	,, 27	5 5 19 A.M.	1 0	S., N.	0·8	0·4	1·6	12·3	—	
2,081	,, 31	0 12 24 P.M.	—	—	—	slight	—	—	—	—
2,082	Sept. 1	6 2 19 P.M.	—	—	—	,,	—	—	—	—
2,083	,, 4	2 50 46 P.M.	—	—	—	,,	—	—	—	—
2,084	,, 4	3 53 5 P.M.	—	—	—	,,	—	—	—	—
2,085	,, 5	4 47 27 P.M.	—	—	—	,,	—	—	—	—
2,086	,, 7	1 6 42 P.M.	—	—	—	,,	—	—	—	—
2,087	,, 8	0 15 9 P.M.	—	—	—	,,	—	—	—	—
2,088	,, 9	8 59 25 P.M.	—	—	—	,,	—	—	—	—
2,089	,, 11	10 3 36 P.M.	—	—	—	,,	—	—	—	—
2,090	,, 15	7 2 45 P.M.	—	—	—	,,	—	—	—	—
2,091	,, 16	4 48 23 A.M.	2 30	S.S.E., N.N.W.	1·1	0·44	1·1	6·5	—	—
2,092	,, 16	8 32 42 A.M.	—	—	—	slight	—	—	—	—
2,093	,, 24	9 16 41 A.M.	—	—	—	,,	—	—	—	—
2,094	,, 26	10 28 43 A.M.	—	—	—	,,	—	—	—	—
2,095	,, 27	10 19 59 A.M.	—	—	—	,,	—	—	—	—
2,096	,, 28	1 43 2 A.M.	3 20	E.S.E., W.N.W.	0·8	1·5	5·9	46·3	0·1	0·1
2,097	Oct. 1	0 36 35 A.M.	—	—	—	slight	—	—	—	—
2,098	,, 6	4 55 53 A.M.	—	—	—	,,	—	—	—	—
2,099	,, 7	11 0 46 A.M.	—	—	—	,,	—	—	—	—
2,100	,, 20	3 16 2 P.M.	—	—	—	,,	—	—	—	—
2,101	,, 26	10 30 47 A.M.	—	—	—	,,	—	—	—	—
2,102	Nov. 6	9 2 24 A.M.	—	—	—	,,	—	—	—	—
2,103	,, 7	2 59 5 A.M.	2 40	E.S.E., W.N.W.	2·0	1·1	1·7	5·4	—	—
2,104	,, 10	10 20 43 A.M.	—	—	—	slight	—	—	—	—
2,105	,, 12	2 46 38 A.M.	—	—	—	,,	—	—	—	—
2,106	,, 12	9 42 19 A.M.	2 10	W.S.W., E.N.E.	0·3	1·2	12·6	263·2	—	slight
2,107	,, 13	11 33 12 A.M.	—	—	—	slight	—	—	—	—
2,108	,, 14	4 6 43 P.M.	—	—	—	,,	—	—	—	—
2,109	,, 20	3 41 12 A.M.	—	—	—	,,	—	—	—	—
2,110	,, 21	9 7 5 A.M.	—	—	—	,,	—	—	—	—
2,111	,, 28	7 2 47 A.M.	—	—	—	,,	—	—	—	—
2,112	,, 28	10 56 10 P.M.	—	—	—	,,	—	—	—	—
2,113	Dec. 4	1 57 0 A.M.	—	—	—	,,	—	—	—	—
2,114	,, 5	0 50 33 A.M.	—	—	—	,,	—	—	—	—
2,115	,, 5	0 13 46 P.M.	—	—	—	,,	—	—	—	—
2,116	,, 13	1 35 38 A.M.	—	—	—	,,	—	—	—	—
2,117	,, 14	3 26 9 P.M.	—	—	—	,,	—	—	—	—
2,118	,, 19	11 59 42 A.M.	—	—	—	,,	—	—	—	—
2,119	,, 21	3 2 15 A.M.	—	—	—	,,	—	—	—	—
2,120	,, 25	1 1 46 A.M.	—	—	—	,,	—	—	—	—
2,121	,, 27	4 49 40 P.M.	—	—	—	,,	—	—	—	—
2,122	,, 30	11 31 40 P.M.	—	—	—	,,	—	—	—	—
					1899.					
2,123	Jan. 1	1 51 1 A.M.	—	—	—	,,	—	—	—	—
2,124	,, 5	9 1 38 A.M.	—	—	—	,,	—	—	—	—
2,125	,, 8	1 10 41 A.M.	—	—	—	,,	—	—	—	—
2,126	,, 14	11 30 35 A.M.	—	—	—	,,	—	—	—	—
2,127	,, 22	8 4 59 A.M.	—	—	—	,,	—	—	—	—
2,128	,, 23	2 51 38 P.M.	—	—	—	,,	—	—	—	—
2,129	,, 29	7 59 33 P.M.	—	—	—	,,	—	—	—	—

21. *Hawaii: Honolulu.*

On February 19, 1898, the trustees of the Elizabeth Thompson Science Fund assigned me a grant of $250 in aid of a seismic survey of the world. This was expended in purchasing a horizontal pendulum, which was shipped to the care of H.M.'s Consul-General, W. J. Kenny, in Hawaii. When Mr. Kenny left Honolulu in March 1899, the instrument was handed to Professor Maxwell, who will work in conjunction with Professor Alexander and Professor Hosmer (Principal of the Government High School), and the latter, I understand, will kindly make arrangements for its installation. Professor George Davidson, Chairman of a Committee appointed by the Council of the University of California to undertake Seismic Investigations, writes me that Mr. Bishop of Honolulu has promised a site for the instrument, and that Professor Alexander will see that it is placed in working order. It is hoped that by next year a series of records will have been obtained from this exceedingly important station. Copies of the report based upon these records should be sent to the Secretary of the Board of Trustees of the Elizabeth Thompson Science Fund, Harvard Medical School, Boston, Mass., through the liberality of which body the Hawaiian Station has been established.

22. *Egypt: Cairo.*

Captain H. G. Lyons, R.E., Director-General of the Survey Department, writes on June 2, 1899, that owing to structural alterations and other causes, it has not been possible to commence continuous observations with the seismograph. The instrument was handed to him in February last, and in about three months' time observations will commence.

23. *U.S.A.: Philadelphia, Swarthmore College.* Professor S. J. CUNNINGHAM.

When observations commenced at this station Professor Cunningham experienced great trouble with 'air tremors,' but from the excellent character of the seismogram for the Mexican earthquake of January 24, 1899, it is anticipated that these difficulties have been overcome, but no report has been received.

III. *Discussion of the preceding Registers.*

Although in the following discussions a few disturbances are referred to in detail, all that is given for the majority are the time entries. The first of these refers to the instant when motion commenced at various stations. It is the commencement of the preliminary tremors referred to as P.T.'s. In the Milne H.P. records these are usually shown as a mere thickening of the line. If there is no entry in this first column it means that heavy motion commenced suddenly, or else in consequence of movements due to air currents the commencement of the P.T.'s was not determinable. The duration of these first P.T.'s, which are regarded as compressional waves which have travelled through the earth, is given where it is possible in the second column. These quantities are not the same as those given in the Shide Register, which refer to the duration of all movement from the commencement up to the maximum. The time of the maximum, which is not the time when the largest group of waves appears, but a point usually midway between this commencement and end, is noted in the third column. The difference between the first and third columns gives the duration of all P.T.'s, and corresponds to entries in the Shide Register. The sum of the first and second columns gives the commencement of the second phase of motion. For the commencement of other phases of motion, of which there may be several before the appearance of the largest waves (L.W.'s.), reference must be made to the seismogram.

For entries in the first column all records should be fairly comparable. The entries in the second column are only comparable in those instances where I have been able to place the seismograms for the stations to which they refer side by side. Where this has been the case will be seen by reference to the reproductions of such seismograms. The accuracy of the determinations of the times given in the third column is dependent upon conditions which govern the accuracy of the entries in the second column. If a station reports a series of times for the first, second, third, &c., sudden increases in range of motion, unless we have the seismograms before us it is by no means certain that these correspond to phases of movement which have been similarly numbered at a second station.

The time entries for Potsdam are only given approximately. (See p. 194.)

The first illustration of these three-column entries is Earthquake No. 182.

Determination of Origins.

The methods by which origins may be determined from time observations are numerous.[1] The simplest, perhaps, is that of circles, and its application is as follows :—If the large waves of an earthquake reach stations B, C and D four, six and eight minutes after reaching station A, then when they reach A the wave fronts are respectively about 600, 900 and 1,200 kms. distant from B, C and D. On a globe with B, C and D as centres I draw circles 600, 900 and 1,200 kms. radius. The centre of the circle, found by trial, which passes through A and touches the circles round B, C and D, is the origin required. The assumption is that whilst the P.T.'s are propagated with variable velocities through the earth, the large waves traverse the surface of the earth with a velocity that is nearly constant. In this illustration I have assumed this velocity to be 2·5 kms. per second.

The observations which support these assumptions are too numerous to require special reference.

With times of arrival at only three stations we are left to decide between two possible centres. See Earthquake 252.

In consequence of the want of sufficient records which are strictly comparable, no attempt has been made in the present report to determine origins with any degree of accuracy.

As an assistance in these determinations the times at which preliminary tremors have been recorded and intervals by which they have outraced the large waves at various stations are not neglected, whilst the topographical and geological character of the locality in which the origin is placed is often an indication as to whether the determinations are correct.

Earthquakes, Nos. 133 *and* 134, September 20 and 21, 1897.[2]

These earthquakes, which were separated from each other by an interval of about ten hours, evidently came from the same origin, and were

[1] See 'Earthquakes,' *Int. Sci. Series*, pp. 200–212.
[2] See *British Association Report*, 1898, p. 211.

connected with the throwing up of a small island off the coast of North-West Borneo, near to Labuan.

The first of these disturbed an electrometer at Batavia at 7h. 14m. 20s. P.M., a magnetometer being disturbed two minutes later. These disturbances indicate the arrival of the larger waves, which coming from Labuan had travelled about 1,660 kms. The velocity of propagation of these movements may be taken at about 2·7 kms. per second. With this assumption the conclusion is that this earthquake originated at about 7h. 4m. 20s. P.M., the time to travel to Batavia having been 10 minutes.

The effect of the second earthquake was to disturb a magnetometer in Batavia at 5h. 22m. 45s. A.M., which by similar reasoning leads to the conclusion that it originated at about 5h. 13m. A.M. At Sandakan, which is about 300 kms. from the origin, it was noted at 5h. 18m. A.M., the inference from which is that the time at the origin would be about 5h. 16m. A.M. The mean between these two determinations gives as an approximation for the true time at the origin 5h. 14m. 30s. A.M.

Apparent Velocity of Preliminary Tremors.

Distance in kms.		Locality of Observation	September 20			September 21		
			Time	Velocity in kms. per sec.		Time	Velocity in kms. per sec.	
On Arc	On Chord			Arc	Chord		Arc	Chord
			H. M. S.			H. M. S.		
—	—	Origin .	7 4 20	—	—	5 14 30	—	—
9046	8302	Nicolaiew .	7 23 30	7·8	7·2	5 27 0	12·0	11·0
10212	9150	Potsdam .	7 26 0	7·8	7·0	5 30 0 (about)	10·9	9·8
10545	9378	Catania .	7 25 2	8·4	7·5	5 29 32	11·6	10·3
10656	9453	Ischia .	7 21 54	10·1	9·0	5 28 12	12·9	11·5
10711	9489	R. di Papa .	7 25 0	8·6	7·6	5 32 8	10·1	8·9
10730	9490	Rome .	7 21 54	10·1	9·0	5 29 42	11·7	10·4
11211	9815	Edinburgh .	7 56 0	3·6	3·1	6 7 30	3·4	3·0
11433	9954	Shide .	7 24 47	9·3	8·1	5 28 51	13·2	11·5

In discussing the above table, the Edinburgh records may at once be excluded as referring to large waves rather than to preliminary tremors. Making this exception then, it will be observed that the velocities for September 21, are greater than those for September 20. Now as these two earthquakes, as recorded in Europe, indicate initial impulses of about the same intensity, it is extremely likely that they radiated from their origins with equal velocities, and therefore the differences seen in the tables in all probability are dependent upon errors in the times calculated for the origins of these shocks for which there is no sure method of correction. On comparing these velocities with velocities determined over paths of similar lengths (see 'British Association Report,' 1897, p. 174) it is noticed that one set of results lie about as much above average determinations, as the other does below the same.

A fair approximation to truth may therefore possibly be obtained by taking the average results recorded for the two shocks. In doing this, Catania, Ischia, Rocca di Papa and Rome, may be placed together as representing a path, which for each is practically 96° in length. The result of this operation is as follows :—

Localities	Distance in degrees	Velocity in kms. per sec. Arc	Chord	$\frac{1}{4}\sqrt{}$ Average Depth in kms.
Nicolaiew	81°	9·9	8·1	8·0
Potsdam	92°	9·3	8·4	9·1
Catania, Ischia / Rocca di Papa, Rome	96°	10·4	9·0	9·5
Shide	103°	11·2	9·8	10·2

The slight discrepancy in the Potsdam record no doubt depends on the want of accuracy in the original observation as indicated in the first table.

The figures in the fifth column express in kilometres one quarter of the square root of the average or mean depth of the chords connecting the origin and each of the observing stations. The close correspondence between these figures and those in the third and fourth columns so long as the records refer to wave paths exceeding 2,000 kms. was pointed out in the Report for 1898, p. 221. These two earthquakes have been discussed by Dr. G. Agamennone in the 'Atti della Reale Accademia dei Lincei,' September 18, 1898, vol. vii. Fas. 6, p. 135. Inasmuch as he has calculated velocities for the preliminary tremors, based on the supposition that the disturbance had only reached the Batavian isoseist when the magnetometers at that station were disturbed, he arrives at velocities practically reaching 30 kms. per second, which are very much higher than those discussed in the preceding tables. He also gives velocity tables for the large waves which are somewhat higher than those which are obtained when it is assumed that the disturbances originated at the times used in our calculations. For example, the shock of September 20, if it originated at 7h. 4m. 20s. apparently gives for the velocities of the large waves results like the following :—

	Velocity in kms. per sec. On Arc	On Chord
First large wave	3·1	2·7
Largest wave	2·7	2·3
Last large wave	1·8	1·6

In calculations of this description the assumption is that all the waves recorded at a distant station left their origin at practically the same time. If this were so, inasmuch as the last trace of movement at Shide took place three hours after the arrival of the preliminary tremors, then the last movement only travelled at a rate of 0·9 km. or 0·8 km. per second, a conclusion that is very improbable. The inference to be derived from the sections in this report relating to Earthquake Echoes (p. 227) and Earthquake Precursors (p. 280) is that the only movements which started from an origin at approximately the same time, are those lying between the first preliminary tremor and the large slow waves representing the maximum motion. The limiting velocities for this earthquake, therefore, lie between 9·3 and about 2·7 kms. per second.

No. 180, March 29, 1898.

	H. M. S. H. M. S.	
Shide	0 5 11 to 23 0 39	Series of disturbances.
Bidston	About these times.	

O 2

These small movements may possibly have been connected with an earthquake noted at Cadiz on March 30.

No. 182, March 31. (Origin, California ?)

	H.	M.	S.	M	H.	M.	S
Shide	8	21	1	4	8	26	1
Nicolaiew	8	22	0	8	8	34	0
Potsdam	—			—	8	26	0
Edinburgh	7	36	30	—	—		

No. 185, April 3.

	H.	M.	S.	M.	H.	M.	S.
Shide	7	38	35	—	7	41	0
Nicolaiew	6	53	0	—	6	58	0
Potsdam	—			—	7	30	0
San Fernando	7	44	4	—	—		

No. 188, April 6.

	H.	M.	S.	M.	H.	M.	S.
Shide	12	37	17	6·0	12	46	0
Toronto	12	44	40	7·0	12	54	44
Potsdam	12	39	0	3·0	12	40	0
San Fernando	12	36	49	—	—		

Origin, Western Atlantic.

The Shide seismogram shows symmetry between the shocks and first echo.

No. 189, April 15. (Origin, California.)

Locality	Commencement			P.T.'s		1st Max.			2nd Max.			3rd Max.		
	H.	M.	S.	M.	S.	H.	M.	S.	H.	M.	S.	H.	M.	S.
Shide	7	47	55	4	0	7	52	55	8	1	0	8	11	0
Nicolaiew	7	54	0	—		7	57	0	—			—		
Rocca di Papa	7	51	0	—		8	2	0	—			—		
Ischia	8	0	0	—		—			—			—		
Potsdam	7	48	0	—		7	57	0	—			—		
Toronto	—			—		7	26	40	—			—		
Edinburgh	7	39	0	—		—			—			—		

The above was noted at about 7.20 A.M., April 15, in California, at Albion, Mendocino Co., where it caused minor damage. The time at which the P.T.'s commenced at Shide, owing to air tremors, is not clearly defined. Neither is this phase clear in the seismogram from Potsdam. Mr. Ralph R. Funk, of Albion, California, writes me with regard to a series of shocks, of which the above is one, saying that 'frequently we would be called to the "phone," and in answering would be asked, "Did you feel that one ?"' The movements reached us about the time of our reply. The other end of the line was about twenty miles inland, and the conclusion is that the shocks must have originated inland. Mr. Funk enclosed with his letter cards from a Draper's self-recording thermometer, showing the effect of shocks upon the record. Between April 15 and 18 I count twenty-two sudden displacements with ranges of from 2 to 10 mm.

Mr. Funk's observations lead to the conclusion that these earthquakes originated at a centrum from forty to sixty miles inland from Albion, and the times of their origin would be about one minute earlier than the times he noted. The time for the particular earthquake here considered would, therefore, be 7h. 19m. A.M.

With this assumption we obtain the following table of velocities :—

	Time of travel		Distance		Velocity of L.W.'s in kms. per sec.
	P.T.'s	L.W.'s	Degrees	On Arc	
Shide	29m.	34m.	75°	8325 kms.	4·0
Nicolaiew	35m.	38m.	91°	10101 ,,	4·4
Rocca di Papa	35m.	43m	98°	9768 ,,	3·7
Potsdam	29m.	38m.	79°	8769 ,,	3·8
Toronto	—	8m.	32°	3552 ,,	7·0 ?

These velocities are distinctly too high, and as the time of arrival of the large waves in Europe is fairly accurate, we must conclude that the shock originated earlier than the time here assumed. For this reason, and for the reason that the times of arrival of the preliminary tremors in Europe do not appear to have been accurately noted, the velocities of these precursors have not been calculated.

No. 192, April 23.

	H.	M.	S.	M.	H.	M.	S.
Shide	9	8	47	3	9	13	0
Potsdam	9	6	0	—	9	12	0

No. 193, April 22-23. (Origin, N.-E. Japan.)

Locality	Commencement			Duration of P.T.'s	Maximum			Remarks
	H.	M.	S.	M.				
Shide	23	58	55	25	0	31	12	Commencement earlier
Rocca di Papa	23	48	40	3	0	23	0	—
Ischia	23	30	0	—		—		—
Catania	23	48	58	—	0	33	47	—
Toronto	23	59	50	25	0	34	26	—
San Fernando	23	59	51	20	0	36	36	—
Potsdam	23	51	0	—		—		—
Nicolaiew	23	47	0	—	23	58	0	—
Tokio		—		—	23	33	49	—

We have here the case of a large earthquake which reached Toronto, Shide, and San Fernando (Spain) and other places at about the same time.

The following accounts of this disturbance are taken from newspapers published in Japan :—

'The sharp shock of earthquake which was felt at Yokohama and Tokio on the morning of the 23rd instant was not unattended with accidents in the north-eastern districts. At Maizawa-cho, Iwata Prefecture, a house was thrown down ; at Nanamiki-cho fissures were produced in the ground at various places ; at Satokawaguchimachi a house was damaged, while the premises of the Kuji Police Station were also affected. At Sanumo, Miyagi Prefecture, two persons are reported to have been injured, while houses and godowns were damaged. At Sendai a large Buddhist image of the Shurin-ji temple was shattered to pieces, and the buildings of the Prefectural Office and other houses all suffered more or less injury. The districts of Ishinomaki, Fukushima and neighbourhood were also a good deal affected, while at Sakata, Yamagata Prefecture, the waters of all rivers overflowed their banks.—*Japan Times.*'

'On Saturday morning (April 23, 1898), at 8.36 A.M., a somewhat strong and prolonged shock of earthquake was felt in Tokio. According to the bulletin issued by the Central Meteorological Observatory, the seismic movement is described as follows :—

Vibration commenced at	8h. 36m. 49s. A.M.
Duration of movement	12m.
Direction of movement	North to South.
Maximum horizontal vibration . . .	8 mm.
Nature of vibration	Slow.

'It is conjectured that the shock was caused by a subsidence of the sea bed in some part of the Northern Pacific. The following table shows the localities where the shock was felt :—

Localities	Time A. M. H.	M.	S.	Nature
Ishikawa	8	34	50	Strong
Fukushima	8	36	40	,,
Akita	8	30	0	,,
Awomori	8	36	0	,,
Yamagata	8	36	0	,,
Utsunomiya	8	36	30	,,
Mayebashi	8	36	34	,,
Kumagai	8	36	39	,,
Niigata	8	37	9	,,
Yokohama	8	36	15	,,
Tokachi	8	29	15	Weak
Mito	8	36	35	,,
Kofu	8	36	53	,,
Nagoya	8	37	40	,,
Yokosuka	8	38	47	,,
Fukui	8	35	0	Faint
Nemuro	8	37	3	,,
Numazu	8	37	53	,,

Japan Mail.'

From a consideration of the above time observations, and from the position of the places at which the movement was severe, it is probable that the origin was from 4° to 5° distant in a north-north-east direction from Tokio. The heavy movement travelled to Tokio at a rate of about 2·5 kms. per second. The time at the origin would, therefore, be 3m. 42s. earlier than that recorded in Tokio, or approximately on May 22 at 23h. 33m. G.M.T. This conclusion is fairly in accord with all the time observations made in Japan, excepting those for Akita and Tokachi.

Professor Ōmori, by different reasoning, places the origin 120 to 200 kms. E.S.E. from Miyako, the time at that place being 23h. 34m. 13s. The time at the origin and the position of the same are, therefore, practically identical with what has been stated, and we have here another illustration of a suboceanic yielding at a depth of from 1,500 to 4,000 fathoms on the face of the western bank of the Tuscarora Deep. That sea waves were not reported indicates that submarine landslips or sudden displacements of materials on the ocean floor were not of marked magnitude.

Place	Time in Transit		Distance			Velocity kms. per sec.		
	P.T.'s	L.W.'s	Degrees	On arc kms.	On chord kms.	P.T.'s on arc	P.T.'s on chord	L.W.'s on arc
	M. S.	M.						
Shide	25 55	58 0	86	9546	8675	6·1	5 6	2·7
Ischia	−3 0	—	87	9657	8756	—	—	—
Catania	15 58	61·0	90	9990	8994	10·4	9·3	2·4
San Fernando	27 0	64·0	99	10989	9672	6·7	5·9	2·8
Potsdam	18 0	—	79	8769	8091	8·1	7·5	—
Nicolaiew	14 0	51·0	75	8325	7743	9·9	9·2	2·7
Toronto	26 50	62·0	89	9879	8915	6·1	5·5	2·4
Rocca di Papa	15 40	50 0	89	9879	8915	10·5	9·4	3·2

No. 195, April 25.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	11	14	17	—			—	
	to 12	25	10					
Kew	11	5	54	—			—	
	to 11	24	0					
Nicolaiew	11	10	30	8	30	11	44	0
Catania	11	40	0	—			—	
Potsdam	11	0	0	(about)			—	

No. 196, April 29.

	H.	M.	S.		H.	M.	S.
Shide	16	39	4	—	16	59	0 (about)
	to 17	37	34				
San Fernando	16	37	19	—		—	
Nicolaiew	16	30	0	—		—	
Rocca di Papa	16	40	0	—	16	43	0
Ischia	16	58	0	—		—	
Catania	16	33	40	—	17	1	4
Bidston	17	0	0 (about)	—		—	
Toronto	16	28	20	—	16	35	5
Potsdam	16	30	0 (about)	—	16	57	0 (about)

The Shide and Potsdam seismograms, although they have definite commencements, are but marked thickenings of the normal trace. The times for maxima are therefore uncertain. The tremors reached Shide at least eleven minutes after reaching Toronto, whilst the large waves at Shide were twenty-four minutes behind those at Toronto. With a velocity of 2·5 kms. per second when the large undulations reached Toronto they would be at a distance of 32° from Shide. Considerations of this description based upon the above data suggest the idea that this earthquake had its origin on the western side of the Atlantic in the direction of the West Indies.

No. 199, May 7.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	6	4	6	—		6	39	0
Kew	6	4	0	7	0	6	10	30
Nicolaiew	6	4	0	—			—	
Rocca di Papa	6	5	30	—		6	14	0
Catania	6	1	40	—		6	45	33
Ischia	6	33	0	—			—	
	or 6	24	35					
Toronto	6	0	42	—		6	16	40
San Fernando	5	57	49	—			—	
Potsdam	5	57	0	—			—	

From the difference in time of the arrival of the maxima movements at Toronto and Shide it is likely that the origin of this earthquake should be sought for in the direction of the West Indies (see Earthquake No. 196).

No. 200, May 20.

	H.	M.	S.		H.	M.	S.
Shide	23	29	5	—		—	
Bidston	23	30	0	—	0	11	0

No. 201, May 22.

	H.	M.	S.		H.	M.	S.
Shide	17	28	15	—		—	
	to 22	50	0	—		—	
Catania	16	33	39	Local earthquake		—	
Madras	17	14	25	—	17	20	1

No. 207, May 30.

	H.	M.	S.		H.	M.	S.
Shide	4	18	55	and	4	28	56
Potsdam	4	18	0	„	5	30	0

No. 210, June 3.

	H.	M.	S.		H.	M.	S.
Shide	17	14	44	—		—	
Kew	10	10	42	—	17	14	30
Nicolaiew	16	57	0	—	17	0	0
Madras. Tremors recorded?							
Potsdam	17	0	0	—	17	9	0

This earthquake crossed Europe from the S.E. towards the N.W.

No. 211, June 19.

	H.	M.	S.		H.	M.	S.
Shide	7	8	50	—		—	
Kew	7	8	24	—		—	
Potsdam	7	0	0	—	7	3	0

Origin probably the same as No. 210.

No. 213, June 21.

	H.	M.	S.	M.	H.	M.	S.
Shide	0	46	42	12	1	0	2
Kew	0	46	18	—	0	59	6
Nicolaiew	0	37	0	—	0	44	0
Rocca di Papa	0	53	20	—	0	58	0

Origin probably the same as No. 210.

No. 214, June 22.

	H.	M.	S.		H.	M.	S.		H.	M.	S.	
Shide . .	6	52	42	—	7	14	42	&	7	13	42	Nine maxima.
to	9	7	42									
Nicolaiew .	6	54	0	—	7	18	0					
Rocca di Papa .	6	45	2	—	6	45	18					
Ischia . .	6	51	48	—		—						
Catania . .	6	51	48	—	6	52	56					
Batavia . .	6	42	18	—		—						
Kew . .	6	54	24,	6h. 56m., 6h. 57m., up to 7h. 5m. At least 12 maxima.								

Origin, Greece?

No. 215, June 29.

	H.	M.	S.	M.	H.	M.	S.		H.	M.	S.
Shide . .	18	48	37	9	19	27	37				
Kew . .	18	47	12	9	19	21	36	or	19	27	0
Nicolaiew .	18	42	0	12	18	59	0				
Rocca di Papa	18	48	42	—	18	59	0	(about)			
Ischia . .	18	50	0	—		—					
or	18	47	47								
Catania . .	18	49	8	—	19	1	5				
Toronto . .	18	43	21	—	18	55	18				
Potsdam . .	18	57	0	—	19	8	0				

At Shide the duration exceeded three hours, the amplitude was 8 mm., indicating a tilting of 4″·8. The period of the large waves was 13·7s., which, with a velocity of 3 kms. per second, indicates a wave-length of 39 kms. The height of these waves may have been 30·2 cm.

The records for the preliminary tremors indicate that the movements commenced at Shide, Kew, Rocca di Papa, Ischia, and Catania about five minutes later than at Toronto. The largest group of waves were recorded at Shide and Kew 26m. or 32m. after they reached Toronto. The corresponding intervals for the remaining stations cannot be inferred with certainty from the above data, as the last column of this for Nicolaiew, Rocca di Papa and Catania apparently refers to the *commencement* of the large motion.

Although the data taken as a whole point to an origin much nearer Toronto than Europe, and the time intervals for large waves noted in Toronto, Kew and Shide suggest an origin on the western side of the Atlantic in the direction of the West Indies, the marked difference in the time at which the first heavy movements were recorded at Shide and Kew throw great uncertainty upon the localising of the originating centre

No. 216, July 2.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	4	27	24		--		—	
Kew	4	25	24		—	4	28	30
Nicolaiew	4	22	0	1	30	4	25	0
Rocca di Papa	4	19	0		—	4	21	0
Ischia	4	19	12		—		—	
Catania	4	19	52		—	4	23	37
Potsdam	4	21	0		—		—	

Origin, Dalmatia. Both the preliminary tremors and large waves have been recorded at distant stations in an expected order.

No. 217, July 2.

	H.	M.	S.	
Shide	17	3	23	The identity of these disturbances is doubtful.
Kew	16	25	48	

No. 218, July 3.

	H.	M.	S.
Shide	21	42	23
Kew	21	44	30

No. 219, July 12.

	H.	M.	S.		
Shide	10	30	0	(about)	The identity of these two shocks is doubtful.
Batavia	11	38	6		

No. 220, July 13–14.

	H.	M.	S.		H.	M.	S.
Shide	23	51	8	—		—	
Catania	0	30	26	—	0	30	26

No. 221, July 14.

	H.	M.	S.	M.	H.	M.	S.	
Shide	17	46	15	15	18	9	27	The P.T.'s are irregular.
Nicolaiew	17	30	0	15	17	52	0	
Potsdam	17	33	0	12	17	54	0	

Origin to the East or South of Nicolaiew.

No. 222, July 20.

	H.	M.	S.		H.	M.	S.
Shide	16	59	26	—	16	59	26
Toronto	(uncertain)			—	17	2	33

Origin, Mid-Atlantic ?

No. 223, July 21.

	H.	M.	S.		H.	M.	S.
Shide	11	35	56	—	11	37	0
Ischia	11	31	0	—		—	
Catania	11	28	41	—	11	33	31
Kew	11	35	0	—		—	

Origin, S.E. Europe ?

No. 224, July 26.

	H.	M.	S.	
Shide	23	21	14	This may be connected with a series of shocks recorded in Valparaiso and Concepcion, one or two of which appear to have been noted in Toronto. (See the *Toronto Register.*)

In a despatch to the Foreign Office, H.M.'s Minister in Chile, Audley C. Gosling, Esq., writes respecting these shocks as follows :—

'I have the honour to report the occurrence on the night of July 23 of severe shocks of earthquake at Concepcion, in Southern Chile, latitude 36° 50′, longitude 73° 10′.

'Nearly every building in the town suffered more or less damage, especially the cathedral and the Bank of Chile and Concepcion.

'The first shock happened at 10.30 P.M. (July 24, 3h. 16m. 30s. A.M. G.M.T.) lasting 30s., with an oscillation of 10 centimetres, direction south-east to north-east, followed by lesser shocks, which continued altogether for twelve hours, and the sea having receded fears were entertained of a tidal wave.

'The winter throughout Chile has been unusually severe and wet, the rainfall in May and June having amounted to 22 inches. Seismic disturbance has been frequent, especially in the neighbourhood of the Andes, where abnormal quantities of snow have fallen. In several passes of the Cordillera snow has attained the extraordinary depth of from 14 to 18 metres, and postal communication has been entirely stopped *viâ* the Andine route for close on two months, many hundred bags of postal matter having been abandoned in the snow by the carriers, several of whom lost their lives whilst performing their perilous duties.

'On the 12th inst. snow fell heavily in Santiago, a very unusual occurrence, to a depth of between 2 and 3 inches: indeed for twelve hours the capital presented the appearance of a city of Northern Europe.

'Valparaiso suffered considerable damage from inundation in the early part of this month, caused by excessive rainfall, which was followed by shocks of earthquake and a severe cyclone, causing considerable destruction to property.'

No. 225, August 8.

	H. M. S.	M. S.	H. M. S.
Shide	8 53 30	—	9 5 0
Nicolaiew	8 25 0	19 0	8 54 0
Potsdam	8 9 0	—	8 45 0

No. 228, August 21.

	H. M. S.
Shide	17 28 0
Bidston	16 50 0

The identity of these shocks is doubtful.

No. 230, August 31.

	H. M. S.	MM.	H. M. S.
Shide	20 5 2	5 to 6	20 36 25
Kew	20 4 0	8	20 35 0
Nicolaiew	20 39 0	—	20 42 0
Rocca di Papa	20 3 40	—	20 31 0
Ischia	20 3 45	—	20 30 0
Catania	20 4 3	—	20 12 33
Toronto	20 17 53	—	21 3 20
Batavia	20 1 18	—	—
Madras	20 2 5	—	20 18 0
Potsdam	20 0 0	—	—
San Fernando (recorded)	—	—	—

At Shide the first P.T.'s lasted about 6 minutes, after which they increased and decreased sometimes gradually and sometimes suddenly up to 20h. 31m. 21s. The maximum was attained at 20h. 36m. 25s., to be followed by its echo of nearly equal magnitude at 20h. 42m. 29s. Following this there were fairly symmetrical sets of earthquake followers. (See Earthquake Echoes, p. 227). The period of the P.T.'s reached 12s., and that of the L.W.'s 15·4s. The maximum amplitude was 9 mm., indicating tilting of 5″·4.

At Kew the chief movements were as follows :—

H. M.		
23 34·9	semi-amp. 5 mm.	or 2″·75
0 37	2·8	1″·55
0 37·8	3·2	1″·75
0 40·7	3	1″·65

It will be observed that the amplitude at Kew is smaller than the one from Shide.

An inspection of the time records shows that the disturbance first reached Batavia and Madras. The heavy movement reached Ischia and Rocca di Papa 12m. or 13m. later, Shide and Kew 18m. later, and Toronto about 45m. later. With the assumption that the large waves travelled at a rate of about 2·5 kms. per second, these time intervals would lead us to look for the origin of this earthquake in the South Indian Ocean eastwards of Madagascar.

No. 231, September 3.

	H.	M.	S.	M.	S.	H.	M.	S.	
Shide .	16	4	48	15	8 ?	16	21	57	Commencement badly defined.
Nicolaiew .	15	32	0	—		16	2	0	
Toronto .	16	17	22	—		16	18	30	
Kew .	15	54	0	—			—		
Potsdam .	3	54	0	—		16	15	0	

The L.W. records for Shide and Toronto would indicate an origin on the west side of the Atlantic, but this does not accord with the records from Potsdam and Nicolaiew.

No. 232, September 13.

	H.	M.	S.		H.	M.	S.	
Shide .	18	11	37	—		—		Record small and not clear.
	to 20	7	35	—		—		
San Fernando .	18	10	49	—		—		
Nicolaiew .	18	7	30	—	18	34	0	
Rocca di Papa .	18	11	38	—	18	11	55	
Ischia .	18	12	0	—		—		
Catania .	18	10	31	—	18	11	27	
Batavia .	18	2	6	—		—		
Toronto .	18	21	45	—	19	15	44	
Kew .	18	11	18	—		—		
Madras .	17	34	25	—		—		
Bombay .	18	53	28	—		—		
Potsdam .	18	0	0	—	19	54	0	

The minuteness and irregularity of the earlier movements render it impossible for Shide, Kew, and other places to give an exact commencement. The large movement recorded in Toronto suggests an origin nearer to that place than to Europe.

No. 233, September 22.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide .	12	30	54	—			—	
	to 13	37	52	—			—	
Kew .	12	46	30	—		13	10	0
Nicolaiew .	12	44	0	9	0	13	19	0
Rocca di Papa .	12	58	0	—		13	33	0 about
Ischia .	12	54	0	—			—	

	H.	M.	S.	H.	M.	H.	M.	S.
Catania	12	40	32	·		Uncertain		
Batavia	12	27	18	—			—	
Madras	12	34	43	—			—	
Bombay	12	40	45	—		12	49	8
Potsdam	12	39	0	—		13	21	0
Mauritius		—		—		13	50	0

No. 234, September 25.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	0 or 12	51	50	—		0 or 12	54	0
Kew	0	50	18	—		0	53	0
Nicolaiew	12	25	0	9	0	12	37	0
Bombay	12	18	37	—		12	20	36

The movement apparently crossed Europe from the east towards the west.

No. 235, October 11.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	16	58	52	—		17	33	39
Kew	16	59	12	—		17	38	42
Nicolaiew	16	49	30	—		17	7	0
Rocca di Papa	16	50	35	—		17	32	0
Ischia	16	50	34	—			—	
Catania	17	3	27	—		17	38	42
Toronto	16	47	29	7	0	17	29	30
Batavia	16	49	42	—			—	
Victoria	16	44	34	4	0		—	
Madras	17	2	36	—			—	
Bombay	17	2	36	—		17	36	42
Potsdam	17	6	0	—		17	30	0 (?)
San Fernando	17	27	19	—			—	

The probability is that this shock *originated* in the Pacific, and after reaching Victoria spread eastwards to Toronto and Europe. In the seismograms received there are several *maxima*, and it seems impossible to recognise similar groups of large waves at different stations.

No. 237, October 12.

	H.	M.	S.	H.	M.	S.
Shide	13	21	2		—	
Kew	13	20	42	13	23	30

No. 238, October 15.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	4	2	44	—		4	30	0
Kew	4	28	0	—			—	
Nicolaiew	3	28	0	37	0	4	10	0
Batavia	4	11	42	—			—	
Madras	3	50	19	—		3	52	25
Bombay	3	46	41	—		3	47	24
Mauritius	4	6	12	—		4	10	0

The disturbance apparently crossed Europe from east to west.

No. 239, November 17.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	13	20	15	—			—	
Kew	13	37	12	—		13	46	24
Nicolaiew	13	3	0	9	0	13	37	0
Rocca di Papa	13	4	40	—		13	46	30

	H.	M.	S.	H.	M.	H.	M.	S.
Ischia	13	30	0	—			—	
Catania	11?	59	33	—			—	
Batavia		—		—		13	12	18
Toronto	13	9	46	—		13	44	50
Victoria	13	7	0	—			—	
Bombay	13	14	19	—		13	34	0
Potsdam	13	0	0	—		13	45	0
Mauritius	13	45	23	—		14	2	0

It seems probable that from its origin the shock radiated westwards to Java and India, whilst eastwards it successively reached Victoria, Toronto, and Europe.

No. 240, December 1.

	H.	M.	S.		H.	M.	S.
Shide	12	48	16	—		—	
Nicolaiew	12	43	0	—	12	54	0
Catania	12	38	11	—	12	49	51
Victoria, B.C.		?		—		—	
Kew	12	51	18	—		—	
Madras	12	45	14	—	12	55	9
Bombay (November 30)	12	43	17?	—		—	
Potsdam	12	42	0	—	12	57	0
Mauritius		—		—	0	58	43?

The Shide seismogram consists of a series of small broadenings of the normal line, like No. 239.

No. 241, December 3.

	H.	M.	S.
Shide	3	18	43
Kew	3	1	18
	and 3	7	0
Nicolaiew	6	18	0?
Potsdam	6	15	0
Bombay	2	49	58?

No. 243, December 3.

	H.	M.	S.
Shide	17	42	26
Batavia	16	59	54

It is doubtful whether these refer to the same shock.

No. 244, December 4.

	H.	M.	S.		H.	M.	S.
Shide	20	20	40	—		—	
Bombay	20	28	5?	—		—	
Mauritius	7	30	0?	—	7	52	0?

No. 245, January 6, 1899.

		H.	M.	S.	M.	S.	H.	M.	S.
Shide		19	11	9	—			—	
Kew		19	3	42	—			—	
	and	19	41	30	—		20	4	12
Nicolaiew		19	23	0	10	0	19	46	0
Rocca di Papa		19	49	0	—		19	52	30
Catania		19	46	11	—		Uncertain		
Toronto		19	9	8	—			,,	
Bombay		19	13	40?	—			,,	
Potsdam		19	9	0	—			,,	
San Fernando		19	14	4	—			—	

No. 246, January 12.

	H.	M.	S.		H.	M.	S.
Shide	3	58	18	—		—	
Toronto	3	47	50	—		—	
Victoria	3	35	16	—	3	36	15
Bombay (January 11)	19	23	44 ?	—		—	

Probably originated in the Pacific, and passed across North America to Europe.

No. 247, January 12.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	9	2	26	—			—	
Nicolaiew	8	37	0	11	0	8	50	0
Batavia	8	4	18 ?	—		8	8	48
Bombay	9	33	24	Dislocation of the line.				

No. 248, January 14.

	H.	M.	S.	M.	H.	M.	S.
Shide	2	48	55	—	3	22	48
Kew	2	58	12	27 ?	3	26	30
Nicolaiew	2	54	0	6	3	32	0
Toronto	2	42	18	13	2	57	6
Victoria, B.C.	2	42	30	9	2	55	28
Bombay (13th)	19	41	37 ?	—		—	
Potsdam	2	54	0	—	3	30	0

We have here well-defined maxima for Shide, Kew, Toronto, and Victoria. The latter place was reached first, whilst at intervals of 2, 29, and 36 minutes, Toronto, Kew and Shide, and Nicolaiew and Potsdam were reached. These data lead to the conclusion that the origin was in the Pacific, at no great distance from the coast of Central America.

No. 249, January 22. Origin, Greece.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	8	22	53	—		8	33	0
Kew	8	22	12	5	18	8	29	0
Nicolaiew	8	19	0	—		8	21	0
Rocca di Papa	8	16	10	—		8	20	40
Ischia	8	14	37	—			—	
Catania	8	14	11	—		8	19	48
Trieste	8	15	48	—		8	21	30
Bombay	9	15	47	Dislocation of the line.				
Potsdam	8	9	0	—			—	
	or 8	18	0	—			—	

This earthquake originated in Greece, and is described in the *Daily Telegraph* of January 23 as follows :—

'Athens, Sunday.

'A severe earthquake shock was felt in several parts of the Peloponnesus early this morning. The shock was most violent in the departments of Philiatra, in the province of Messinia, and Kyparrisia, in the province of Laconia, the two most fertile and beautiful districts of the peninsula. Several villages are completely destroyed, and in the towns practically every house is uninhabitable.

'The loss of life would have been very great had not the majority of the inhabitants, warned by the first shocks, left their houses in the early morning, and camped in the open plains and fields. A great many, however, have been injured, and several are killed, though it is impossible at present to state the exact number.

'The people, panic-stricken, have been in the fields all to-day, and are in a distressing condition.

'The greatest efforts must be made to give them the urgent succour which is necessary.—*Central News*.'

The fact that the large waves reached Trieste, Rocca di Papa, and Nicolaiew at about the same time, and the English stations 10 minutes later, also indicate that the origin of this shock was in Greece.

No. 250, January 24–25. Origin, Mexico.

	H.	M.	S.	M.	S.	H.	M.	S.
Time at the origin		—			—	23	43	31
Shide	23	47	42?		—	0	34	42
Kew	23	47	24	9	0	0	35	30
				or 43	24			
Nicolaiew	23	57	30	4	0	0	12	0
				or 10	0			
Rocca di Papa	0	0	0		—		—	
Catania	0	1	43		—	Uncertain		
Toronto	23	50	24			0	7	10
Victoria, B.C.	23	51	7		—	0	4	10
Trieste	23	58	24		—	0	48	0
Bombay (25th)	12	57	59?		—		—	
Potsdam	23	48	0		—		—	
Mauritius		—			—	1	15	45
						and 1	19	0

At Shide the early part of the disturbance is eclipsed by air tremors. The first echo, the amplitude of which is equal to that of the maximum at 0h. 34m., was at 0h. 37m. The Kew record is distinctly smaller than the one from Shide, the amplitudes at these places being 4 mm. and 6 mm. respectively.

The following notes throw light upon the nature of the shock near to its origin, and other disturbances, with which it has been confused.

The Sub-Director of the Central Meteorological and Magnetic Observatory in Mexico, Senor José Zandejas, writes to Professor R. F. Stupart of Toronto, as follows:—

'Owing to the temporary absence of Senor Barcena, I have great pleasure in answering your favour of January 26 last, and inform you that the shock of earthquake on the 24th of the same month was felt here at 5h. 23m. (local time) and lasted 2 minutes, causing some damage to old buildings, but cannot be classified as very strong. Generally they are not in the capital. It was felt from Vera Cruz on the east to St. Blas on the west, both seaports, one in the Gulf and the other on the Pacific, declining towards the south to the Pacific Ocean and Tehuantepec Isthmus, including the States of Jalisco, Colima, Michoacan, Guerrero, Pueblas, Flaxcala, Mexico, Oaxaca, and Vera Cruz, which is the territory where earthquakes are generally felt and in which the volcanos of the Republic are situated.

'As these phenomena have not been sufficiently studied, it would be hazardous to point out a determinate point of convergence of their probable origin, but it has been noticed that the greatest intensity and frequency of these earthquakes take place in the States of Michoacan, Guerrero, Oaxaca, and Chiapas to Guatemala, &c., and might extend with still greater violence to the Pacific Ocean.'

In a subsequent letter Senor Zandejas corrects the above time to January 24, 5.29 A.M., and adds that there was a second shock at 5.9 P.M. (mean local Mexican time). The former was slight and the latter was strong.

The *United States Monthly Weather Review* for January gives the following note :—

'Reports from Mexico describe the earthquake of Monday evening, January 24, as the severest ever known in the City of Mexico. The first oscillation began at 9·09 (local time). It was from north-east to south-west, and lasted 1m. 56s. Three minutes later came a second shock, which lasted 5s., oscillating north-west and south-east. The earthquake was felt over the entire Republic of Mexico. At Colima it lasted 1m. 20s.; at Vera Cruz it lasted 10s. But few reports of this earthquake have been received from the United States, although it must have been feebly felt at many stations.

'At San Barnardino, Cal., a shock was felt at 4.55 P.M., January 25. The newspapers of that city state that the shock was of little greater severity than usual, and that the barometer dropped from 30·12 to 29·86, "an unusual occurrence, &c."'

Mr. O. H. Howarth, who is interested in recording earthquakes, writes to me from Hacienda de Zavalita, Oaxaca, Mexico, as follows :—

'I think you may be interested to have a local note about the earthquake shock which occurred here on Tuesday, January 24, being the longest and strongest I have yet experienced in this country. The time was 5.25 A.M., and the duration, as near as I could get it, 20 seconds. We are situated here about 13 miles south-west of the city of Oaxaca, in a winding cañon, well up into the mountain range: altitude, 6,200 feet. We seem to be all agreed that the wave approached from the south. The formation of the whole district here is a very hard gneissic granulite in which occur the quartz veins with gold. The feature which struck me most was the sensation (which I have not experienced before), of the wave grinding its way through a hard resisting medium. Just at the climax there was a peculiar jerk, as if it had changed its direction, or met with some exceptional obstruction. The noise was considerable, and some of our people were on their knees saying their "Ora pro nobis" with great vigour. One of them told me to watch the clouds, and for three hours afterwards I noticed heavy mist down upon the high ridge at the head of the cañon (8,700 feet), which otherwise we never see at this time of the year—the middle of the dry season. I cannot see any direct reason for an atmospheric change, but there is no doubt that a big condensation occurred. The shock seems to have been unusually long and severe in the city of Mexico (200 miles north from here)—1m. 36s. (this I doubt), and damage was done at some points; but probably the accounts which reach England will be exaggerated as usual.'

On May 29 Mr. Howarth again wrote me, saying that in Oaxaca where he was (200 miles south from Mexico City), there was a severe shock at 5.25 A.M., a slight tremor about 11 A.M., and another slight shock about 5 P.M. In Mexico City this was reversed, the slight shock being at 5.23 A.M. and the heavy one causing damage about 5 P.M. The first coming from the south to reach Mexico City would have to traverse the great range of Popocatepetl, Ixtaccehuall, and Ajusco, by which it would be absorbed or diverted, and therefore whilst strong in Oaxaca, it would be feeble in Mexico City. If the second came from the north or north-west these effects would be reversed. The only effect at Zavalita, near Oaxaca, on January 24, was to crack walls, and to bring down a load of loose rock at the entrance to a mine tunnel, and in this way it acted as a service. In Oaxaca the intensity of local shocks is remarkably variable at short distances.

The conclusion we arrive at from the above notes is that we have to deal with the shock felt severely in Mexico at 5.9 P.M., or at 11h. 45m. 31s. G.M.T. The time at the origin would be about 2m. earlier than this, or 11h. 43m. 31s.

Velocities of transit, on the assumption that the disturbance originated at 23h. 43m. 31s.

Place	Time of Transit		Length of path			Velocities in kms. per sec.		
	P.T.'s	L.W.'s	Degrees	Arc	Chord	P.T.'s		L.W.'s
						Arc	Chord	Arc
	M. S.	M. S.		KMS.	KMS.			
Shide .	4 11	51 11	80	8880	8170	35	32	2·5
Kew .	3 53 or 12 53	51 59	80	8880	8170	38 or 11·5	35 or 10·5	2·6
Nicolaiew .	14 1	28 29	100	11100	9744	13·1	11·5	6·4?
Rocca di Papa .	16 21	—	92	10212	9150	10·4	9·3	—
Catania .	18 12	—	97	10767	9526	9·8	8·7	—
Toronto .	6 53	23 39	30	3330	3292	8·0	7·9	2·3
Victoria, B.C. .	7 36	20 39	34	3774	3719	8·2	8·1	3·0
Trieste .	14 53	64 21	91	10101	9072	11·3	10·2	2·6
Bombay .	14 28?	—	141	15651	11990	—	—	—

Because the commencement of the Shide seismogram is partially eclipsed by air tremors, there is no certainty in the determination for the time of transit of the P.T.'s. The Kew seismogram is perfectly clear, and shows a very small movement, commencing at 23h. 47m. 24s., which nine minutes later is reinforced by slightly larger tremors. The commencement of this second group leads to the determination of the velocities 11·5 and 10·5 kms. per second. Records from Shide, Kew, Toronto, and Victoria, which relate to large waves, are distinctly comparable, and the resulting velocities are fairly in accord to what previous investigations would lead us to expect. The velocities obtained for the preliminary tremors are, however, apparently too high, and suggest that the time determined for the origin of the shock is a little late. When more definite information is obtained from Mexico this may be altered.

The amplitude of the first maximum and the time interval to its 'echo.'

	Interval	Amp.
	M. S.	MM.
Shide	3 0	6
Kew	6 30	3·5
Toronto	5 0	7·5
Victoria	4 30	17

A good seismogram has been received from Swarthmore, Penn., U.S.A., but its time scale has not arrived in time for publication.

No. 251, January 30.

	H.	M.	S.		H.	M.	S.
Shide	18	55	42	—		—	
Kew	18	45	48	—		—	
Nicolaiew	17	59	30	—	18	25	0
Victoria, B.C.		?		—		—	
Madras	17	48	19	—	17	52	25
Bombay	17	50	16	—	17	58	34

No. 252, January 31.

	H.	M.	S.		H.	M.	S.
Shide	11	22	47	—	11	25	0
Kew	11	21	48	—	11	25	0
Toronto	11	36	0	—	11	37	12
Victoria, B.C.	11	40	0	—	11	41	26
Bombay	12	23	20	Dislocation.			

The time intervals for the L.W.'s indicate an origin to the south of the Azores or off the coast of North Norway.

No. 253, January 31.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	17	32	31	2	30	17	35	0
Kew	17	31	18	—			—	
Nicolaiew	17	1	30	12	30	17	15	0
Bombay	17	16	21	—			—	

No. 254, February 23.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	13	47	23	2	0	13	49	53
Kew	13	49	30	—			—	
Bidston	12	50	0	—			—	
Toronto	Uncertain			—		14	4	0
Victoria	14	6	40	—		14	8	33

The time intervals for the L.W.'s suggest an origin west of Cape Verd.

No. 255, February 26.

	H.	M.	S.		H.	M.	S.
Shide	13	47	29	—	13	48	0
Kew	13	49	0	—		—	
Victoria	14	6	23	—	14	8	24
Trieste	13	48	18	—	14	0	42

Origin probably near to that of No. 254.

No. 256, February 27.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	10	12	19	—		Light out		
Kew	11	27	30	—			—	
Nicolaiew	11	31	30	2	30	11	37	0
Toronto	11	41	10	—		11	42	20
Victoria		?		—		11	48	0
Bombay	10	42	20	Dislocation.				
San Fernando	11	35	49	—			—	

Origin probably the same as 252, 254, and 255.

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No. 257, February 27.

	H.	M.	S.		H.	M.	S.
Shide	15	26	40	—		—	
Kew	15	27	12	—		—	
Trieste	15	28	12	—	15	40	30
Bombay	14	40	50	Dislocation.			

No. 259, February 28.

	H.	M.	S.		H.	M.	S.
Shide	19	47	38	—	19	48	38
Kew	19	48	30	—		—	
Toronto	20	0	15	—	20	1	0
Victoria	20	5	0	—		—	
Trieste	19	50	12	—	20	4	30
Bombay	20	9	23	Dislocation.			
San Fernando	19	56	49	—		—	

Origin like 255, &c.

No. 260, February 28.

	H.	M.	S.		H.	M.	S.
Shide	23	1	5	—		—	
Trieste	22	42	48	—	23	14	30

No. 262, March 6.

	H.	M.	S.		H.	M.	S.
Shide	20	52	31	—	20	56	0
Nicolaiew	20	30	0	—	20	34	0
Kew	20	36	42	—		—	

No. 263, March 7.

	H.	M.	S.		M.	S.	H.	M.	S.	
Shide	1	31	1 ?		—		1	53	42	P.T.'s eclipsed by air tremors.
Kew	1	17	42		—		1	53	24	
Nicolaiew	1	5	0		10	0	1	22	0	
Rocca di Papa	1	13	0		—		1	52	0	
Ischia	1	30	0		—			—		
Catania	1	18	14		—		1	19	23	
Toronto	1	19	29		—		2	1	0	
Victoria, B.C.	1	15	13		—		1	16	15 ?	
Trieste	1	6	54		—		1	42	48	
Bombay	0	3	47 ?		—			—		
Mauritius, Mar. 6,	23	20	0	to	Mar. 7,		1	35	0	
San Fernando	1	49	49		—			—		

This earthquake had its centre in Central Japan, but until the time of its origin is more definitely known its complete discussion is impossible. The *Japan Mail* of March 11 gives the following description of the occurrence :—

'The earthquake on the 7th instant belongs to the category of serious shocks. Our daily life in this country is perpetually disturbed by tremblings and shakings, which become at last so familiar that we scarcely notice them. Yet not a few of these ugly visitors fall short of calamitous dimensions by only a narrow margin, and the unconcern with which we receive them is simply the result of habit. Apparently the centre of disturbance on the 7th instant was somewhere in the vicinity of Osaka.

Such, at least, is the conclusion arrived at by the Meteorological Bureau, though the record of damage done suggests that Nagoya may share the honour. The time telegraphed from Nagoya is 9.45 A.M., and that telegraphed from Osaka 9.56, but it is not possible to place much reliance on these figures. Nagoya city does not seem to have suffered. The damage occurred chiefly at Ono, Handa, and Chirin, where houses are said to have been overturned. Wakayama, also, was severely visited, houses and go-downs being overthrown in the two districts of Nishi-mura and Higashi-mura. The most accurate accounts come from Osaka. There the direction of the shock was from south-east to north-west. At first vertical, the movement presently became horizontal, the latter phase, which lasted about two minutes, developing the maximum intensity. Apparently the only personal injuries were not directly due to the shock, but resulted from a panic among the employees at the Osaka Cotton-spinning Factory. In attempting to escape from an upper story, several fell downstairs, and twenty-eight were hurt, two severely. Fuller details may show, however, that the falling of chimneys and buildings was not unaccompanied by loss of life.

'Considering the wide area through which the seismic disturbance on the 7th instant was felt, it is inferred that the origin of the force must have been at a point very deep below the surface. The great majority of the earthquakes experienced in this country are of distinctly limited scope. Thus the statistics collected by the Seismological Bureau show that out of 2,670 shocks felt in 1891, only eight were felt throughout an area of over 10,000 square miles. The great earthquake on August 28 in that year made itself perceptible throughout an area of 15,750 square miles, and the shock on the 7th of this month had a range of 15,000 square miles. The latter did not reach farther north than Yokohama: it was not felt at all in Tokio.

'A telegram received by the Home Department from Nara Prefecture gives details of the damage done by the earthquake :—"A strong shock was felt at 10 A.M. on the 7th. At Takata-machi twenty farmers' houses fell, and two children were buried in the ruins. At Sakmaimachi a man was crushed to death. Other damage is in course of investigation."

'A telegram received subsequently says : "The result of investigation shows that three persons were killed and 11 injured, 67 houses destroyed and 24 damaged. The mountains in Amanowawa Mura, Yoshino district, shook greatly and emitted a thunderous sound, and the ground opened in parts, landslips occurring here and there. Roads westward of Hirase have been broken away in places."

'Ten workers in the Tenwa mine were buried alive, but were dug out safely.'

-----	Time of transit of L.W.'s	Distance	Velocity per sec. on arc
	M.	°	KMS.
Shide	59	87	2·7
Kew	59	86	2·7
Nicolaiew	26	74·5	5·2 ?
Rocca di Papa	56	88	2·9
Catania	24	90	6·9 ?
Toronto	65	95	2·7
Trieste	47	84·5	3·3

The velocity of transit for the P.T.'s is not given, because small errors in the time observations lead to marked discrepancies in the final results.

A point of interest in the seismograms is that whilst at Shide and Kew the range of motion was 3 and ·8 mm., at Toronto it was only ·5, and at Victoria, the nearest station to the origin (71°), the movement was barely visible, and so indefinite that certain determinations of time are impossible. This latter place would be reached along a path entirely beneath the Pacific, Toronto by a path crossing Behring Straits, and Shide by a land path across Asia and Europe.

Observations of this nature suggest that oceanic waters exert a damping effect upon the earth waves traversing their beds.

No. 264, March 12.

	H.	M.	S.	M.	H.	M.	S.
Shide	9	55	10	9	10	26	12
Kew	9	55	42	—		—	
Nicolaiew	9	41	30	25	10	11	0
Toronto	9	52	11	—	9	58	7
Victoria, B.C.	9	49	55	—	9	59	30
Trieste	9	53	6	—	10	7	18
Batavia		—		—	10	8	12
Bombay	10	31	41	—		—	
Calcutta	8	51	20	—		—	
Mauritius		—		8h. 20m. to	10	50	0

The L.W. records for Toronto and Victoria, followed 13 and 27 minutes later by records at Batavia and Shide, suggest an origin in the Mid-South Pacific.

No. 266, March 19.

	H.	M.	S.
Shide	13	45	35
Victoria	13	15	43
Trieste	1 ?	24	12
Toronto	13	24	29 ?
Calcutta	12	36	18

This disturbance probably travelled from the western side of North America towards Europe.

No. 267, March 21.

	H.	M.	S.		H.	M.	S.
Shide	14	58	47	—	15	38	17
Kew	15	25	30	—		—	
Trieste	14	46	24	—	15	22	12
Catania	14	46	24	—	14	57	30
Calcutta	14	43	6	—		—	
San Fernando	15	58	19	—		—	

The movement apparently crossed Europe from the east or south-east.

No. 268, March 23.

	H.	M.	S.	M.	S.	H.	M.	S.
Shide	10	45	16	18	0	11	16	18
Kew	11	0	30	—		11	20	12
Toronto	10	41	52	—		11	6	0
Victoria, B.C.	10	35	47	—		11	17	17
Trieste	10	42	48	—		11	5	6
Catania	10	34	15	—		11	9	48
Bombay	11	42	30	—		11	47	46
San Fernando	11	40	34	—			—	

Apparently we have two small shocks, and it is difficult to discriminate between the commencements of the first and the second. For Shide, Toronto, and Victoria the times of the L.W.'s refer to the second disturbance, which may have originated on the western side of the Atlantic.

No. 269, March 23.

	H.	M.	S.		H.	M.	S.	
Shide	14	57	41	—	14	59	0	First of three maxima.
Kew	15	0	24	—	15	14	42	
Victoria, B.C.	14	55	20	—	15	5	11	
Trieste	14	30	0	—	14	47	24	
Toronto		—		—	14	45	47?	
Catania	14	18	1	—	14	54	45	
Calcutta	13	12	38	—		—		

No. 270, March 25.

	H.	M.	S.		H.	M.	S.
Shide	14	53	19	—	15	28	0
Kew	14	54	0	—		—	
Toronto	14	44	37?	—	14	46	57
Victoria, B.C.	14	46	25	—	15	0	12
Trieste	14	53	30	—	14	55	18
San Fernando	14	52	19	—		—	

To suit the L.W. intervals for Toronto, Victoria, and Shide, an origin may be sought on the West Coast of South America.

No. 271, March 25.

	H.	M.	S.
Shide	20	39	52
Kew	20	46	6

Earthquakes recorded at Shide, I.W., and also at distant stations, between February 27, 1898, *and April* 3, 1899.

Milne's H. P. (Photographic Record)									H.P. with Mirror (Photographic)			Bifilar Pendulum (Photographic)			H.P. and Ordinary Pendulums (Mechanical Registration)		
Shide, I.W.	Kew	Toronto	Victoria, B.C	San Fernando	Madras	Bombay	Calcutta	Batavia	Mauritius	Nicolaiew	Potsdam	Trieste	Bidston	Edinburgh	Rocca di Papa	Ischia	Catania
174	..	..	..	..	..	..	..	..	..	..	..	..	..	▬	..	..	..
179	..	..	..	..	..	..	..	..	..	..	..	..	..	▬	..	..	..
180	..	..	..	..	..	..	..	..	..	..	..	..	▬	▬	..	..	..
182	..	..	..	..	..	..	..	..	..	▬	▬	..	..	▬	..	..	..
185	..	..	..	▬	..	..	..	..	..	▬	▬	..	..	..	..	..	..
188	..	▬	..	▬	..	..	..	..	..	..	▬	..	..	..	..	..	..
189	..	▬	..	..	..	..	..	..	..	▬	▬	..	..	▬	▬	▬	..
192	..	..	..	▬	..	..	..	..	..	..	▬	..	..	..	..	..	..
193	..	▬	..	▬	..	..	..	..	..	▬	▬	..	..	..	▬	▬	▬
195	▬	..	..	..	..	..	..	..	..	▬	▬	..	..	..	▬	..	..
196	..	▬	..	▬	..	..	..	..	..	▬	▬	..	..	..	▬	▬	▬
199	▬	▬	..	▬	..	..	..	..	..	▬	▬	..	..	...	▬	▬	▬
200	..	..	..	..	..	..	..	..	..	..	..	..	▬	..	..	..	..
201	..	..	..	..	▬	..	..	..	..	..	..	..	..	..	..	..	▬
207	..	..	..	..	..	..	..	..	..	..	▬	..	..	..	..	..	..
209	..	..	..	▬	..	..	..	..	..	..	..	..	..	..	..	..	..

EARTHQUAKES RECORDED AT SHIDE, I.W. &c.—*continued.*

Milne's H. P. (Photographic Record)									H.P. with Mirror (Photographic)			Bifilar Pendulum (Photographic)			H.P. and Ordinary Pendulums (Mechanical Registration)		
Shide, I.W.	Kew	Toronto	Victoria, B.C.	San Fernando	Madras	Bombay	Calcutta	Batavia	Mauritius	Nicolaiew	Potsdam	Trieste	Bidston	Edinburgh	Rocca di Papa	Ischia	Catania
210	—	..	..	..	..	..	..	..	..	—	—	..	..	..	..	..	..
211	—	..	..	..	..	..	..	..	..	..	—	..	..	..	..	..	..
213	—	..	..	..	..	..	..	..	..	—	..	..	..	..	—	..	..
214	—	..	..	..	..	..	..	—	..	—	—	..	..	..	—	—	—
215	—	—	..	..	..	..	..	..	..	—	—	..	..	..	—	—	—
216	—	..	..	..	..	..	..	..	..	—	—	..	..	..	—	—	—
217	—	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
218	—	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
220	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	—
221	..	..	..	..	..	..	..	..	..	—	—	..	..	..	..	..	..
222	..	—	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
223	—	..	..	..	..	..	..	..	..	..	..	..	..	..	..	—	—
225	..	..	..	..	..	..	..	..	..	—	—	..	..	..	..	..	..
228	..	..	..	..	..	..	..	..	..	..	..	..	—	..	..	..	..
230	—	—	..	—	—	..	..	—	..	—	—	..	..	..	—	—	—
231	—?	—	..	..	..	..	..	..	..	—	—	..	..	..	..	..	..
232	—	—	..	—	—	—	..	—	..	—	—	..	..	..	—	—	—
233	—	..	..	..	—	—	..	—	—	—	—	..	..	..	—	—	—
234	—	..	..	..	..	—	..	..	..	—	..	..	..	..	..	..	..
235	—	—	—	—	—	—	..	—	..	—	—	..	..	..	—	—	—
237	—	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
238	—	..	..	..	—	—	..	—	—	—	..	..	..	..	..	..	..
239	—	—	—	..	..	—	..	—	—	—	—	..	..	..	—	—	—
240	—	—	—	..	—	—	..	..	—?	—	—	..	..	..	..	..	—
241?	—	..	..	..	..	—?	..	..	..	—	..	..	..	..	..	..	..
242	..	..	..	..	..	..	..	..	..	..	—	..	..	..	..	..	..
244	..	..	..	..	..	—	..	..	—	..	..	..	..	..	..	..	..
245	—	—	..	—	..	—	..	..	..	—	—	..	..	..	—	..	—
246	..	—	—	..	..	—	..	..	..	..	..	..	..	..	..	..	..
247	..	..	..	..	..	—	..	—	..	—	..	..	..	..	..	..	..
248	—	—	—	..	..	—	..	..	..	—	—	..	..	..	..	..	..
249	—	..	..	..	..	—	..	..	..	—	—	—	..	..	—	—	—
250	—	—	—	..	..	—	..	..	—	—	—	—	..	..	—	..	—
251	—	—	—	..	—	—	..	..	..	—?	..	..	..	..	..	..	..
252	—	..	—	..	..	—	..	..	..	..	..	..	..	..	..	..	..
253	—	..	..	..	..	—	..	..	..	—?	..	..	..	..	..	..	..
254	—	..	—	..	..	..	..	..	..	..	..	..	—	..	..	..	..
255	—	..	—	..	..	..	..	..	..	..	..	—	..	..	..	..	..
256	—	—	—	—	..	—	..	..	..	—	..	..	..	..	..	..	..
257	—	..	..	..	..	—	..	..	..	..	..	—	...	..	..	..	..
259	—	..	—	—	..	—	..	..	..	..	..	—	..	..	..	..	..
260	..	..	..	..	..	..	..	..	..	..	..	—	..	..	..	..	..
262	—?	..	.	..	..	..	..	..	..	—	..	..	..	..	..	..	..
263	—	—	—	..	..	—	..	..	—	—	..	—	..	..	—	—	—
264	—	—	—	..	..	—	—	—	—	—	..	—	..	..	..	..	..
266	..	..	—	..	..	..	—	..	..	..	..	—	..	..	..	..	..
267	—	..	..	..	..	..	—	..	..	..	..	—	..	..	..	..	—
268	—	—	—	..	..	—	..	..	..	..	..	—	..	..	..	..	—
269	—	..	—	..	..	..	—	..	..	..	..	—	..	..	..	..	—
270	—	—	—	..	..	..	..	..	..	..	..	—	..	..	..	..	..
271	—	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Totals . 67	42	23	18	13	8	24	4	9	8	35	29	13	4	5	18	15	22

Records were kindly sent to me from Rome, Pavia, Livorno Castello, and Catanzaro, which unfortunately arrived too late for insertion in this report.

Earthquakes recorded at Shide and at Distant Stations.

The preceding table shows the earthquakes which were recorded in the Isle of Wight and also at distant stations. When comparing the records at one station with those taken at any other station, consideration must be given to the dates on which these stations commenced their observations. For example, the Kew entries corresponding to those at Shide lie between Nos. 195 and 271 or April 25, 1898, and March 25, 1899. Just as comparisons may be made between the Isle of Wight list and that from Kew, showing that many earthquakes were recorded at the former place which were not recorded at the latter, exactly opposite comparisons might be made. For example, whilst the above list indicates that Kew only recorded forty-two disturbances out of fifty-seven noted at Shide, the complete register for Kew (p. 166) indicates that at that place seventy-five disturbances were noted, and it is possible that more than forty-two of these were common to other countries.

Although the Indian stations have recorded earthquakes which have also been observed in other parts of the world, in consequence of difficulties largely the result of a tropical environment the value of many seismograms has been impaired. Until these difficulties have been overcome the frequency of earthquakes common to India and other parts of the world can only be imperfectly indicated.

Although the instruments at Bidston and Edinburgh have yielded excellent results respecting slow changes in the vertical, and as such are important adjuncts to a seismological laboratory, yet the above table indicates that they fail to pick up many earthquakes.

Analysis of the Table from a Seismometrical Point of View.

The last line of the table shows that Kew, Toronto, Victoria, Bombay (?), Nicolaiew, Potsdam, and Trieste have recorded more earthquakes in common with the Isle of Wight than have been recorded at the Italian stations. This conclusion is more clearly indicated in the following table :—

Out of	57	records at Shide	42, or	73	per cent., are	common to	Kew
,,	61	,,	23 ,,	37	,,	,,	Toronto
,,	32	,,	18 ,,	56	,,	,,	Victoria, B.C.
,,	42	,,	9 ,,	21	,,	,,	Batavia
,,	60	,,	35 ,,	58	,,	,,	Nicolaiew
,,	48	,,	29 ,,	60	,,	,,	Potsdam
,,	20	,,	13 ,,	65	,,	,,	Trieste
,,	66	,,	25 ,,	38	,,	,,	Italy

If the Italian stations are taken separately the percentage for each is lower than that for Italy as a whole. When we compare the twenty-four earthquakes recorded at Shide, Nicolaiew, and Potsdam which lie between Nos. 182 and 250 with those noted in Italy, we see that six of these, viz. Nos. 182, 185, 210, 231, 248, and 264, apparently escaped observation in the latter country.

Again, out of thirteen disturbances noted in Trieste and in the Isle of Wight, only six of these, viz. Nos. 255, 257, 259, 260, 264, and 266, are found in the Italian register. It will also be observed that some of the shocks which escaped the Italian instruments were well recorded in Toronto, Victoria, B.C., Batavia, and other places; and it may be added that if we except Nos. 182, 260, and 266, the seismograms representing these shocks from Shide, Potsdam, and other places are of marked magnitude.

Although it may be suggested that these omissions in the Italian registers of earthquakes which have spread over large portions of the world are due to a want of sensibility in the instruments employed in that country, such an explanation does not accord with the fact that these same instruments with their frictional indices pick up the small preliminary tremors of large earthquakes with apparently the same exactitude as the seismographs do which record photographically.

Whatever may be the true explanation of these *lacunæ*, it must be remembered that the open diagrams from the Italian instruments furnish information not obtainable from the majority of the photographic apparatus, and they are, therefore, indispensable to fully equipped laboratories.

Time Intervals between the arrivals of Earthquakes in Victoria, B.C., Toronto, and Shide.

1. *Intervals in Minutes between the arrival of P.T.'s and L.W.'s at Toronto and Shide after reaching Victoria.*

No. of Shock	Toronto	Shide	Toronto	Shide	
	M.	M.	M.	M.	
235	3 P.T.'s	14 P.T.'s	—	—	
239	3 „	13 „	—	—	
246	12 „	23 „	—	—	
248	0 „	7 „	2 L.W.'s	28 L.W.'s	
250	—	—	3 „	31 „	Origin, Mexico
266	9 „	30 „	—	—	
268	6 „	10 „ ?	—	—	

As it is known that No. 250 originated in the vicinity of Mexico it may be inferred, from the similarity in time intervals, that No. 248 originated from the same region. No. 246 probably travelled from the Pacific in an east direction through Victoria across North America to Toronto and on to Shide. Nos. 235 and 239 had similar origins well out in the Pacific considerably to the south of Victoria. The group, as a whole, apparently represents adjustments along the western frontier of the North American continent.

2. *Intervals in Minutes between the arrival of P.T.'s and L.W.'s at Toronto and Victoria after reaching the Isle of Wight.*

No. of Shock	Toronto	Victoria	Toronto	Victoria
	M.	M.	M.	M.
188	—	— P.T.'s	9	— L.W.'s
252	—	— „	12	16 „
254	—	— „	15	19 „
256	—	— „	x	$x+6$ „
259	3	18 „	13	—

The above shocks probably originated on the eastern side of the Mid-Atlantic, along the line of the Azores and Cape Verde Islands, or off the coast of Norway.

3. *Intervals in Minutes between the arrival of P.T.'s and L.W.'s at Victoria and Shide after reaching Toronto.*

No. of Shock	Victoria	Shide	Victoria	Shide
	M.	M.	M.	S.
264	—	— P.T.'s.	1	28 L.W.'s.
270	2	9 „	14	42 „

Origins probably in the Mid-South Pacific.

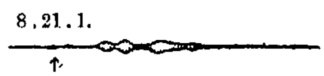
A shock from Japan, No. 263, reached Victoria first, whilst two and four minutes later it reached Shide and Toronto.

Illustrations of Seismograms.

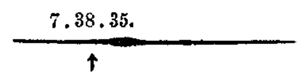
The following illustrations of seismograms are only to be regarded as *sketches* of the original photograms. They show the range of motion and principal characteristics of wave-groups, but they do not show details like small serrations clearly exhibited in the records from which they are derived. The numbers correspond with the numbers given for particular earthquakes in the preceding text. The arrow with its time-mark gives the time for a particular phase of movement, which is usually that of the commencement. The number following the letter S gives the time-scale in millimetres per hour. Thus S=60 means that 60 millimetres equal one hour.

The locality at which a seismogram was obtained is indicated by the following initial or initials :—

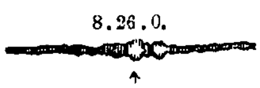
Isle of Wight . . .	I.W.	Bombay . . .	B.
Kew	K.	Calcutta . . .	C.
Toronto	T.	Batavia . . .	Ba.
Victoria, B.C. . . .	V.	Mauritius . . .	M.
San Fernando . . .	S.F.	Potsdam . . .	P.
Madras	Md.	Philadelphia . . .	Ph.



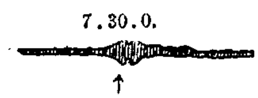
No. 182.—I.W. S=59.



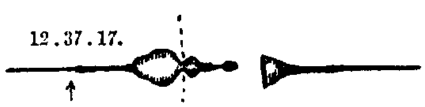
No. 185.—I.W. S=59·5.



No. 182.—P. S=20.



No. 185.—P. S=20.

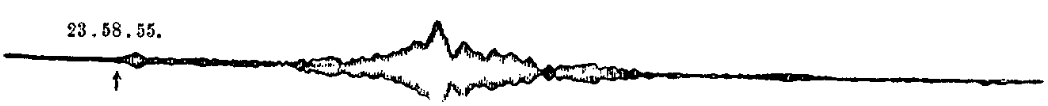


No. 188.—I.W. S=59.

No. 189.—I.W. S=59·5.

No. 188.—T. S=58·25.

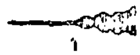
No. 189.—P. S=20.



No. 193.—I.W. S=59.

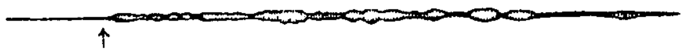
No. 193.—T. S=58·5.

23.51.0.



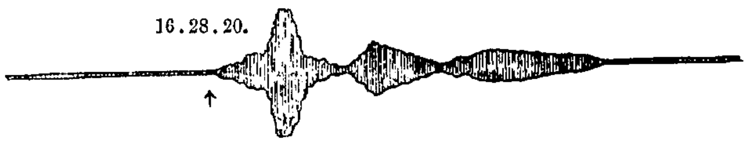
No. 193.—P. S=20.

16.39.4.



No. 196.—I.W. S=59·75.

16.28.20.

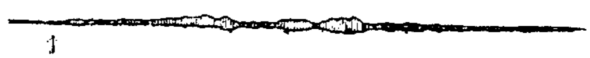


No. 196.—T. S=59.

16.30.0.

No. 196.—P. S=20.

16.37.18.



No. 196.—S.F. S=60.

6.4.6.

No. 199.—I.W. S=59.

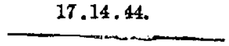
5.57.0.

No. 199.—P. S=20.

6.0.42.

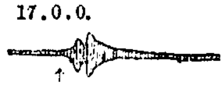
No. 199.—T. S=59.

17.14.44.

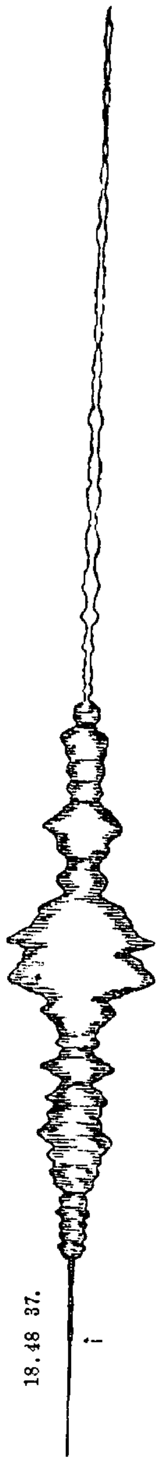


No. 210.—I.W. S=60.

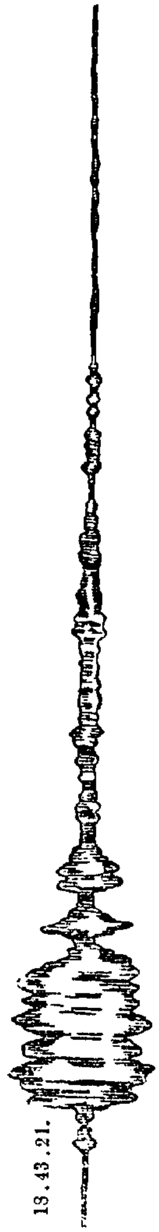
17.0.0.



No. 210.—P. S=20

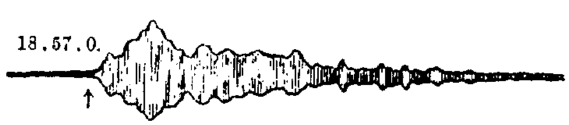


No. 215.—I.W =60. (Also see Figs. 3 and 4.)

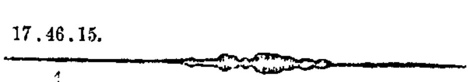


No. 215.—T. S=57·5.

No. 215.—K. S=61



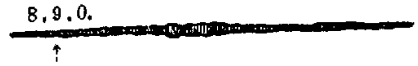
No. 215.—P. S=20.



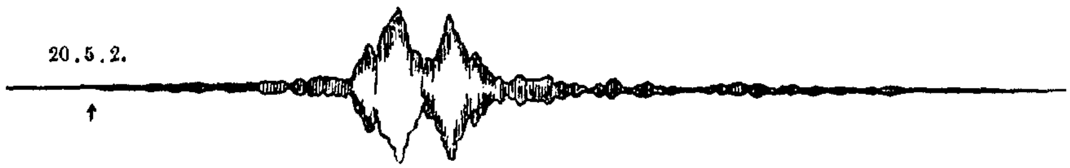
No. 221.—I.W. S=59·5.

No. 225.—I.W. S=59·5.

No. 221.—P. S=20.

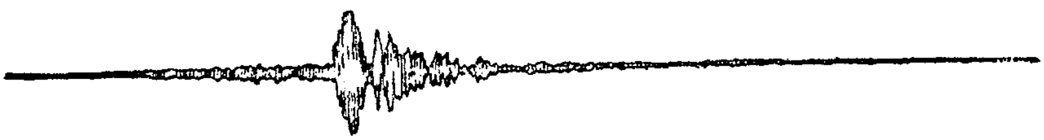


No. 225.—P. S=20.

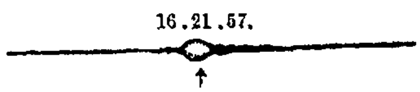


No. 230.—I.W. S=59·25. (Compare with Fig. 2, p. 228.)

No. 230.—K. S=61.



No. 230.—Ba. S=60·5.

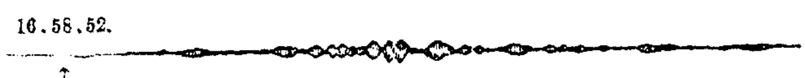


No. 231.—I.W. S=59·5.

No. 231.—P. S=20.

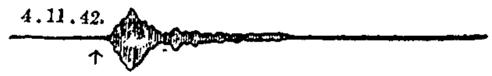
No. 232.—P. S=20.

No. 232.—T. S=59.

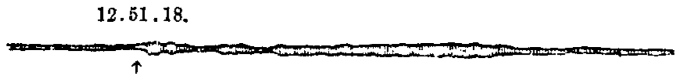


No. 235.—I.W. S=59·5.

No. 235.—T. S=58.



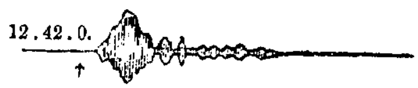
No. 238.—B. S=59.



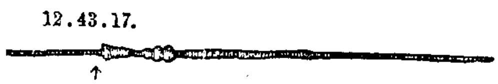
Toronto, Oct. 21. S=58·25.

No. 239.—B. S=59.

No. 240.—I.W. S=59.

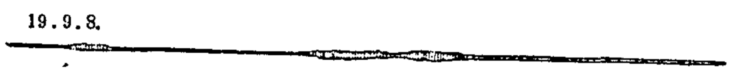


No. 240.—P. S=20.

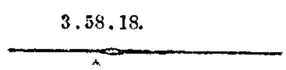


No. 240.—B S=59.

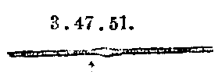
No. 245.—I.W. S=58.



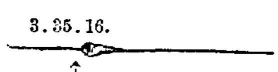
No. 245.—T. S=58·75.



No. 246.—I.W. S=58.

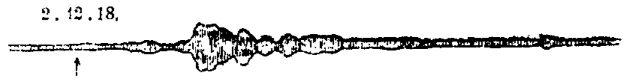


No. 246.—T. S=58.



No. 246.—V. S=60·5.

No. 248.—I.W. S=58.

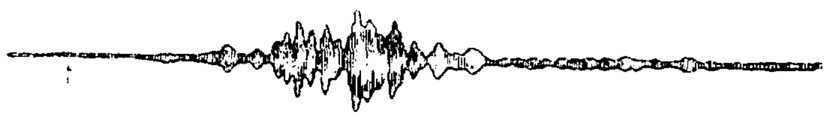


No. 248.—T. S=58.

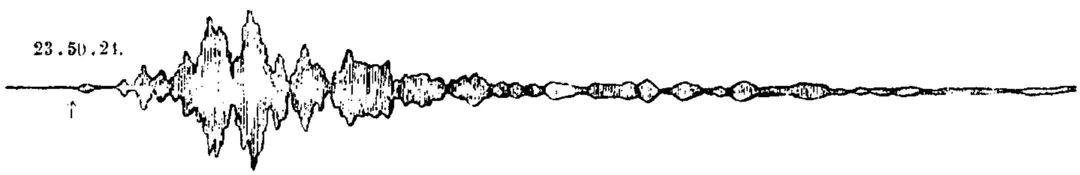
No 248.—V. S=60.

No. 250.—I.W. S=60.

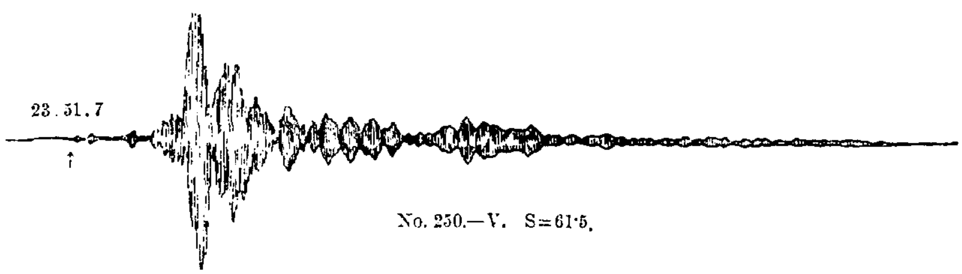
No. 250.—K. S=61.



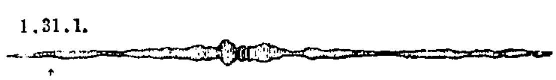
No. 250.—Ph. S=61.



No. 250.—T. S=58·5.



No. 250.—V. S=61·5.



No. 263.—I.W. S=58·25.

No. 263.—T. S=59.

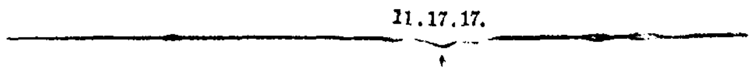
No. 264.—I.W. S=58·25.

No. 264.—T.

No. 264.—V. S=60·75.

No. 268.—I.W. S=58·5.

No. 268.—T. S=58·25.



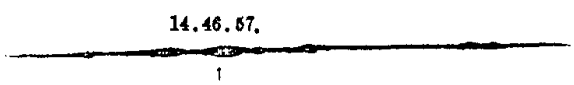
No. 268.—V. S=60·5.

No. 269.—I.W. S=58·25.

No. 269.—V.

No. 270.—I W. S=58·5.

No. 270.—V.



No. 270.—T. S=59.

IV. *Varieties of Earthquakes and their Respective Durations.*

Those who live in a country where earthquakes are frequent must have observed that the shocks they feel may at least be divided into two groups. The members of one of these groups are phenomena characterised by their short duration and by the rapidity of their vibrations. The other group, which in Tokio form about 5 per cent. of the whole, can be felt for several minutes, and the period of movement is long. With many persons earthquakes having this character produce feelings of nausea, and there is abundant evidence to show that they represent undulations of the surface of the ground. By the former of these groups, although they may sometimes alarm a city, free horizontal pendulums, unless constructed like a bracket seismograph, are seldom disturbed, whilst the latter throw such instruments into violent and fitful motion which, rather than extending over two or three minutes, continues for as many hours.

One class of earthquake consists of what are practically elastic vibrations, which have a short life and do not travel to great distances from their origin, whilst the other class gives rise to surface waves which are propagated to very great distances.

The earthquakes which are merely elastic shiverings may possibly be represented at their origin by a blow delivered on a small surface, whilst those which are shiverings accompanied by surface heaving are the result of collapse in and along an extensive region.

If we divide earthquakes into these two groups, between which connecting links, if they exist, are very rare, we then see an escape from the prevalent idea that as earthquakes radiate their duration apparently increases.

Although we know that preliminary tremors outrace large waves, that both of these forms of movement increase in period, and that a single wave at one station may at a more distant station be represented by two waves, all of which phenomena tend to the spreading out of a disturbance, it is difficult to realise that an earthquake recorded in Japan as having a duration of two or three minutes should, when it reaches this country, be represented by movements continuing over two or three hours. The circumstances which have led to this supposition are twofold. First, no distinction has been drawn between the two kinds of earthquakes ; and, secondly, the duration of a disturbance near to its origin has been determined by a method very different from that by which it was determined at a distance.

When these considerations are neglected the results we may arrive at are well illustrated in a paper on 'Earthquake Duration' by Dr. E. Odone ('Atti della Reale Accademia dei Lincei,' vol. iv. fas. 10, p. 425). We here find a list of twenty-four earthquakes, the origins of which were at distances varying between 25 and 11,170 kms. from Rocca di Papa, Rome, and Siena. At these places the duration of these shocks were noted by fairly similar seismographs of the heavy pendulum type. A glance at this table apparently indicates that the durations of these earthquakes had steadily increased with the distances of their origins from the observing stations. With an origin at a distance of, say, 25 kms., we find a duration of about 70 seconds, whilst if the origin was at a distance of 9,000 kms. the duration becomes 4,800 seconds.

For the first members of this series, which I will call local shocks, had the instruments employed been free horizontal pendulums it is very doubtful whether they would ever have been recorded, neither would they have been noted had the pendulums with their multiplying indices been at distances of a few hundred kilometres from their origins. The common experience, based on seismographic records of local shiverings in Japan, is that the duration of movement decreases with distance from an origin, and it is only very large earthquakes which can be recorded with steady point seismographs at distances exceeding 300 miles.

Directly we come to the other members in the list we are apparently dealing with the duration of earth tilting, and with regard to any particular earthquake we may ask for information respecting the duration of the same near to its origin or at stations between this point and Central Italy, or in countries further afield. The information we have on these points is, however, scant, but such as exists is far too definite to be ignored. For example, Dr. Odone gives in his list the Japan earthquake of March 22, 1894, on which occasion the seismographs at Rocca di Papa and at Rome were respectively agitated for 1h. 3m. and 1h. 20m.

Because the duration of this earthquake as recorded by a bracket seismograph in Tokio was ten seconds, it must not be assumed that we have here an illustration of a seismic movement increasing in its duration as it radiated. On this occasion, after feeling the first heavy movement, I went to my observatory and watched the boom of a horizontal pendulum follow very irregular heavings of the ground for some fifteen minutes, when I was joined by my colleague, Mr. C. D. West, and we continued to watch the erratic, fitful movements for 1h. 47m. longer.

We have in this instance—and others might be quoted—distinct evidence of earth movements near to their origin continuing for a very much longer period than they were observable at distant localities. What was noted in Europe were the earthquake precursors or preliminary tremors, the duration of which increases with distance from an origin, and, after that, the earthquake echoes with possible traces of waves which had travelled round the world in a direction opposite to that constituting the maximum phases in the seismograms. In Tokio, although the preliminary movements were of shorter duration than in Europe, the total duration of the disturbance in that city, on account of the great length of the concluding vibrations, seems to have exceeded that which was recorded in Italy.

The shiverings of our world recur on the average every thirty minutes, but the heavy breathing or true ground swell does not happen more than once a week. Popularly they are both earthquakes, but they differ in their character, in their duration, and probably in their origin, and as they radiate, their life, as exhibited at stations farther and farther remote from their origin, rather than increasing becomes less.

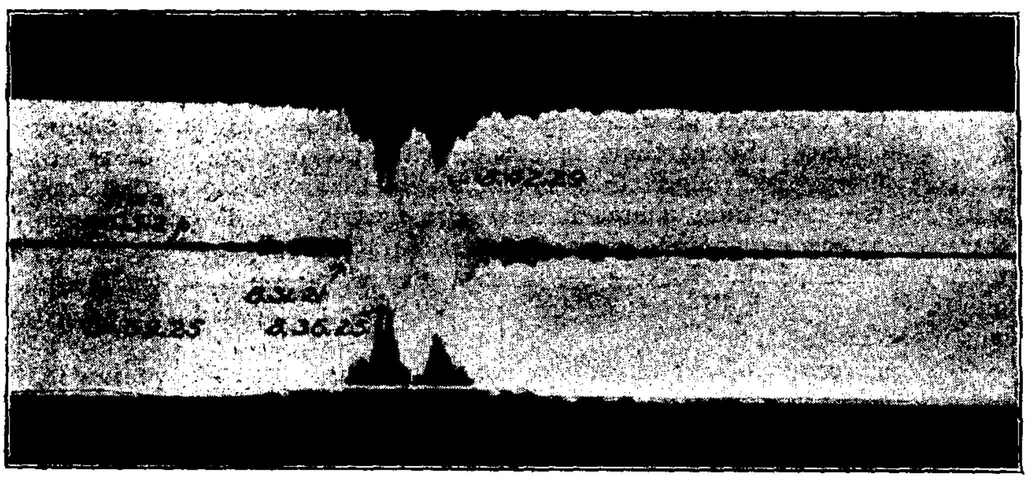
V. *Earthquake Echoes.*

(This and the following Section are in part abstracted from Notes published in 'Nature,' February 16 and March 1, 1899.)

An earthquake disturbance as recorded at a station far removed from its origin shows that the main movement has two attendants, one which precedes and the other which follows. The first of these by its characteristics indicates what is to follow, whilst the latter in a very much more pronounced manner will often repeat at definite intervals but with decreasing intensity the prominent features of what has passed. Inasmuch as these latter rhythmical but decreasing impulses of the dying earthquake are more likely to result from reflection than from interference I have provisionally called them Echoes.

When an earthquake is comparatively small, and has originated as a single effort at no great distance (one or two thousand miles) from the observing station, the seismogram shows a single set of preliminary tremors, of short duration, a single set of pronounced vibrations corresponding to irregularly delivered originating impulses, and finally a series of concluding vibrations which rise and fall in value every three or four minutes. That which appears on a seismogram as a two-blow earthquake terminates with dual reinforcements. As illustrative of this I may refer to the Isle of Wight seismogram of the South Indian Ocean earthquake of August 31, 1898 (see Earthquake No. 230). We have apparently here two large disturbances—the first I regard as the shock, and the second as its echo. They are followed by pairs and groups of echoes. If we closely examine the group of movements which I call the shock, and compare the same with its echo (the second pair being too small to exhibit details), we find that the sub-divisions of each roughly agree in character; each shows five phases (three of which are very distinct) of the same relative magnitudes. After this we get another five-phase group, followed by two groups each of four phases, beyond which point rhythmical recurrence is lost.

Fig. 2—Shide, Isle of Wight, August 31, 1898.
Duration, 2h. 18m. 0s. Max. Amp. = 9 mm. = 5″·4.

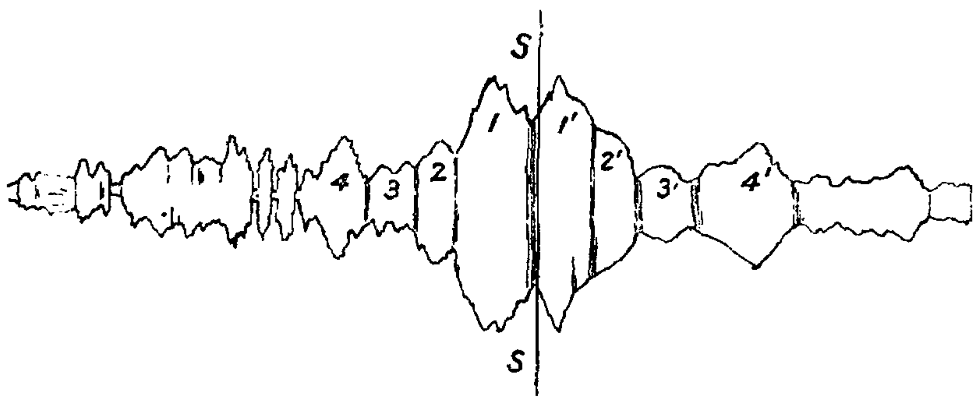


A very good illustration of what may be multiple echoes is found in the Isle of Wight seismogram for June 29, 1898 (see Earthquake No. 215). This is a very large earthquake which probably caused the whole of the earth to pulsate, and the duration of its preliminary tremors indicates that it originated at a very great distance. It had a duration exceeding three hours. The main disturbance shows more than fourteen maxima of motion which have a fairly symmetrical arrangement to the right and left of a central dividing line. In the accompanying figure (Fig. 3), which is an enlargement (1·7 times) of the central portion of the original seismogram, the line of symmetry is marked SS. To the left of this is the main shock 1, and on the right is its echo, 1′, a repetition common to many earthquakes. That violent shocks are, a few minutes later, sometimes followed by a second severe movement, is well recognised in certain earthquake countries. In Japan they are called the Uri Kaishi, or return shaking, and conditions leading to their production are readily imagined. All that can be said about 2, 3, 4, and 5 is that they have approximately the same characters as 2′, 3′, 4′, and 5′, but inasmuch as the first series have travelled more quickly than 1, whilst the latter have travelled more slowly than 1′, it is difficult to recognise the latter as echoes of the former. Beyond 5′ the vibrations suddenly become small, but they apparently show such a marked repetition in form and uniformity in their time of recurrence that these characteristics can hardly be the result of accident. To facilitate comparison these have been enlarged, and are here reproduced, the later group being placed beneath those which arrived earlier. (Fig. 4.)

The triangularly-headed echo 2′ is not unlike 2 ; its spherically formed successor 3 is repeated in 3′ ; and so we may continue through the series until we reach the gourd formed 9 and 10 reflected in corresponding shape by 9′ and 10′.

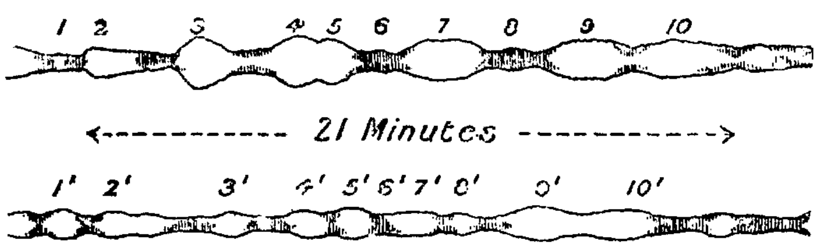
The time intervals between these corresponding groups are from twenty-

FIG. 3.



eight to thirty-one minutes. We here appear to be dealing with a series of vibrational groups each of which took almost exactly half an hour to travel to and fro between two reflecting surfaces or districts. If the waves were compressional in character the distance between these surfaces would be about 8,000 kms., but if they travelled with the velocity

FIG. 4.



of the waves of shock this distance would be reduced to something under 3,000 kms. From their period and amplitude it is probable that the distance lies between these values.

The main point at issue, and the one to be answered before we enter into further speculations, is whether seismograms showing this musical-like repetition can be interpreted in the manner here suggested. The concluding vibrations of an earthquake have usually been regarded as a disorderly mob of pulsatory movements resulting from spasmodic impulses which gradually grew feebler as the activity at a seismic centre became exhausted. The question before us is whether an earthquake dies by a process analogous to repeated and irregular settlements of disjointed materials, or whether it is simply a blow or blows which come to an end with musical reverberations inside the world. For the present my opinion inclines to the latter, and I see in the earthquake followers the likeness of their parents.

VI. *Earthquake Precursors.*

The series of movements to which I now refer is the procession of vibrational groups which run before the main disturbance, with the smaller of which, under the name of preliminary tremors, we are already more or less familiar. These precursors have in several respects characters which are exactly the opposite to those of the earthquake followers. They have a definite commencement, and with large earthquakes group after group usually increases suddenly in amplitude and period.

Another characteristic of the precursors is that whilst group after group may grow larger, they become more and more irregular in their contours. The first of the preliminary tremors, if they ever had any *frétillements* have lost the same, whilst those which follow carry serrations which are marked. This observation, together with that of growth in amplitude, suggests the idea that each group of precursors starting from a common origin has reached an observing station by different routes: the first have come along the path of least time, and the latter, culminating in the shock, along paths continually approximating to that of free surface waves.

Now and again we see in groups of preliminary tremors a likeness in contour and arrangement of what is to follow. Near to an origin they may have a duration of from 1 or 2 up to 10 or 20 seconds, and their period has been recorded at from $\frac{1}{5}$ to $\frac{1}{20}$ of a second. When they are preceded by a sound wave, we have evidence of a very much higher frequency. If these vibrations have travelled long distances and through our earth, most records indicate a period of 3 or 4 seconds. Records from Rome have shown periods of less than half a second, but even these are probably much too large. My own records only indicate a slight switching at the end of a light elastic boom, or that the same has been moved very rapidly to and fro relatively to its steady point. Until a steady point seismograph with extremely light multiplying indices or some other special form of apparatus has been employed as a recorder, our knowledge of this end of the seismic spectrum is not likely to increase.

The last points connected with the earthquake precursors are the intervals of time which elapse between the arrival of the first tremor and the largest wave or waves corresponding to the originating impulse and the duration of the first series of preliminary tremors. As measured on seismograms for disturbances which have originated at different distances from the Isle of Wight Observing Station, these two intervals are given in the following table :—

Origin	Distance in degrees	First P.T. to Max. motion in minutes	Duration of first group of P.T.'s in minutes
Iceland	17°	4 or 5	1·4
Greece	22°	6	3
Tashkend	48°	14	8
Hayti	62°	30	13*
Japan	84°	47	8·5
Borneo	112°	55	6·0

* This is dependent on a single observation, and may be too high.

These figures are too few in number to be used as a foundation for any certain conclusions, but they may possibly indicate results to be sought for in future records. With regard to the first set of intervals, we know that for distances up to 8° from an origin that the time by which tremors outrace the main movement may be reckoned by seconds. Adding this fact to our list, it seems that here we have a table which indicates that as earthquakes travel at first the tremors only outrace the large waves at a very slow rate, but as the distance from the origin increases this rate increases. This goes on until a point between 48° and 62° distant from the origin has been reached, after which the rate at which the large movements are left behind decreases.

One explanation for this is to suppose that the first precursors came through the earth with an average velocity which observation shows to increase approximately with the square root of the average depth of the chord joining the centrum and the observing station, whilst the large waves travelled round the surface. One objection to this view is that observations exist which show the large waves have apparently travelled over paths varying between 20° and 110° at rates which, rather than being constant, have increased from 2·1 to 3·3 kms. per second.

The velocities giving this comparatively slight difference were however determined on the assumption that the times at which various earthquakes originated were known, and there is therefore a possibility that they may be apparent rather than real.

Also it must be remarked, as pointed out by Dr. C. G. Knott, that if we regard the large waves as being distortional, inasmuch as the coefficient of elasticity determining the velocity of propagation of such waves may not be greatly influenced by pressure, it is quite conceivable that they should follow the preliminary tremors through our earth. The question then arises, whether these larger movements would be left farther and farther behind their precursors in the manner indicated.

When we come to our second set of intervals, which indicate the duration of the first preliminary tremors before they are eclipsed by groups of vibrations, which usually grow in size, and appear from their periods to be distortional, we see that up to a point about 62° from an origin these figures apparently increase, but beyond that point they grow less.

What we have to explain, in addition to this fact, is that of the continuity and growth in magnitude of what very often forms a long and continuous series of preliminary motions. As I have already stated, their very appearance indicates that they have travelled on different paths. The first have followed a path entirely through our earth, whilst its successors have travelled shorter and shorter distances through the earth to meet a crust, through which they have completed their journey to the observing station. The first followed Knott's brachistrochronic path, or that of least time, whilst the successors took paths the latter parts of which were along arcs of increasing length. The result of this would be that at an observing station vibrations would arrive in series, each group corresponding to an originating impulse. The last of the rabble would be the series representing that portion of the main shock which had travelled entirely round and through the crust.

To complete this hypothesis, I here reproduce a sketch given to me by Dr. C. G. Knott, showing the probable form of wave fronts and paths of compressional vibrations passing through our earth.

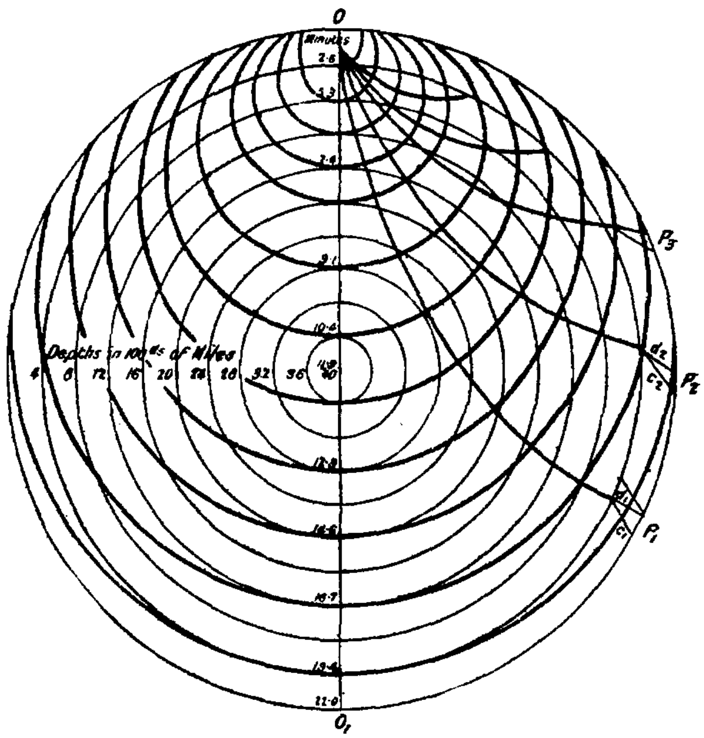
The assumption on which this is based is that the square of the speed of the movements is a linear function of the average depth, which corresponds, as already indicated, with observation.[1]

The result at which Knott arrives indicates that the square of the speed increases at 0·9 per cent. per mile of descent in the earth, the formula being

$$v^2 = 2{\cdot}9 + {\cdot}026d \text{ in mile second units.}$$

With an initial velocity of 1·7 mile per second the velocities at depths of 400, 800, 1,200, ... 4,000 miles, are 3·7, 4·9, 5·8, 6·7, 7·4, 8·1, 8·7, 9·3, 9·8 and 10·3 miles per second. The times taken for wave fronts to

FIG. 5.



reach the positions shown are indicated in the diagram, the time taken to pass through the earth being twenty-two minutes.

I assume that when a wave has passed from its origin beyond the region vaguely referred to as the crust of our earth, it then spreads in all directions through a mass in which there is only an extremely gradual change in elasticity and density with regard to its centre. All wave paths, however, before they emerge at the surface, encounter at varying obliquities the under surface of this crust. For purposes of illustration we will assume this region of abrupt change to lie on the 400-mile circle. The path P_1 meets this nearly at right angles, whilst P_2 P_3 meet the same at decreasing angles less than right angles. After each of these incidences a condensational wave will be refracted and split up into condensational and distortional rays. Now it will be observed that these two waves, which I will call c and d, will have different distances to travel before

[1] See *Brit. Assoc. Report*, 1898, p. 221.

actual emergence, which distances will increase from P_1 towards P_3. Directly d_1 emerges, not only will c_1 be eclipsed, but also c_2 c_3, coming from the direction P_2 P_3, will also be hidden.

At some point like P_3, when the duration of the preliminary tremors reaches a maximum on towards the origin, the quantity will decrease, if only on account of the fact that the velocity along the brachistrochronic ray differs less and less from that of the distortional wave within the crust. Such a view may possibly explain the rise and fall in the values of our last column.

The growth in amplitude of the groups of tremors may be due to the fact that the first group has travelled on the path OP_1, whilst the second has travelled OP_2 P_1, &c., whilst the crests of these groups, especially of those immediately in advance of the large waves, should roughly agree with the impulses which these represent.

VII. *On Certain Disturbances in the Records of Magnetometers and the Occurrence of Earthquakes.* *By* JOHN MILNE.

In the 'British Association Reports for 1898,' pp. 226-251, a large number of records were brought together, showing what has happened at or about the time of large earthquakes to magnetic needles at various Observatories. These records may be classified as follows :

1. Those which show that magnetographs have very frequently been disturbed at the time when their foundations have been moved by the large but unfelt waves of earthquakes originating at a great distance. Examples of such movements are to be found in the registers from Utrecht, Potsdam, and Wilhelmshaven. For the particular kind of earth movement referred to, magnetic instruments at these places furnish records of value to the seismologist.

2. Those which show that magnetographs are seldom, and then only very slightly, or in some instances apparently never disturbed at the time of large earthquakes. This appears to be the case at Greenwich, Kew, Falmouth, Stonyhurst, Pola, Vienna, Copenhagen, and Toronto.

3. Those which show that magnetic needles have exhibited perturbations, frequently of considerable magnitude, a short time before the occurrence of large earthquakes. As illustrative of such observations, reference may be made to the registers from Zikawei, Mauritius, Utrecht, and Greenwich. Similar observations have been made in Japan.[1]

On pp. 248-251 of the above-mentioned report, an attempt is made to explain these observations, whilst to extend the same I append the following table received from P. Barrachi, Director of the Melbourne Observatory.

Declinometer Disturbances observed at the Observatory, Melbourne.
P. BARRACHI, Esq., *Director.*

The magnetographs at Melbourne are of the same form and dimensions as those at Kew. The value of an ordinate of 1 inch in the curves is very nearly 29′, and the time scale corresponds to 14·7 inches for twenty-four hours.

In dealing with the curves for Observatory purposes—as, for instance, taking mean values, &c.—oscillations whose amplitudes are less than 2′

[1] See *Seismology*, Int. Sci. Series, pp. 225, 226.

are not considered disturbances, but much smaller oscillations than these can easily be detected in the curves. In order to avoid any arbitration as to what disturbance should be singled out for the purpose of comparing with the list of earthquakes, in cases where the curves appeared to be generally disturbed, or where more than one disturbance occurred, or where several disturbances presented different characteristics, Mr. Barrachi has put down in the following notes all the distinctive features of the curves occurring within several hours, in some cases 10 or 12 hours, before and after the times specified in the earthquake register, noting also every appreciable oscillation, however small, so that those who make comparisons may discriminate for themselves. All times in the list are indicated as Melbourne Mean Astronomical Time, the day commencing at Melbourne noon, the hours being reckoned from 0 to 24. By amplitude is meant the whole range of displacement. Period means the time taken for the double swing. When there is a movement from the neutral line upwards and back to the same, followed some time later by a movement downwards and back to the same, the latter is said to be in the 'opposite phase' to the former. As these two movements may be independent of each other it will be recognised that the term 'opposite phase' is one of convenience. 'Superimposed waves' means that there are small waves which appear as regular or irregular, large or small, serrations on the trace of larger waves.

The earthquake list referred to by the numbers, dates, and times in the first three columns is given in the 'British Association Report' for 1898, p. 227.

Melbourne astronomical time is 9h. 39m. 53·8s. in advance of Greenwich.

1889.

		M.M.A.T. H.	M.	
1	April 18 .	3	1	Minute wave from 1h. 40m. to 1h. 45m., amp. under 30″ followed by still minuter waves from 2h. 0m. to 2h. 20m.
2	July 11 .	20	2	Minute oscillations commenced 13h. 45m. to 14h. 5m., amp. under 20″, larger oscillations of longer period, amp. above 2′, from 14h. 15m. to 17h. 45m., maximum amp. at 17h. 20m. about 3′.
3	„ 28 .	13	10	Slightly disturbed from 15h. 40m. to 18h. One oscillation of long period from 15h. 0m. to 15h. 22m., amp. above 2′, followed by minute waves of shorter period. Commencement (more accurately), probably 15h. 35m. No other disturbance before that hour appears on this curve.
4	„ „ .	15	40	(see above)
5	Aug. 25 .	17	17	Decided disturbance commencing 9h. 50m., with one oscillation, amp. $3\frac{1}{2}$′, period 40m., followed by another wave, amp. $5\frac{1}{2}$′, time of max. amp. 11h. 5m., then followed by less marked and irregular oscillations for 6h., gradually becoming normal shortly after.

1891.

		H.	M.	
6	Oct. 27 .	19	18	Curve disturbed from 7h. 5m. max., disturbances at 7h. 5m., with a large wave amp. 6′, period 33m., and at 14h. 40m., with a large wave in opposite direction, amp. 7′, period 47m., followed by minute waves of very short period till 22h.

1892.

		H.	M.	
7	Mar. 16 .	11	2	Slight, but well marked disturbance, commenced 8h. 30m. ending 9h. 35m., consisting of two waves, amp. from 4′ to 5′.

		M.M.A.T. H.	M.	
8	Mar. 16.	15	2	Curve very slightly disturbed, from 12h. 50m., showing minute waves of irregular period and amp., but less than 2′. Almost normal after 15th.
9	April 19.	9	10	No disturbance.
10	May 12.	3	23	Minute, sudden, and very short disturbance commencing 23h. 45m., May 11, duration 6m., consisting of two minute waves, amp. 1′.
11	Oct. 19.	2	1	Sudden decrease of E. declination indicative of sudden disturbance, commencing 1h. 10m., max. amp. of disturbance 6′, followed by minute waves of two hours, amp. only a few seconds of arc. Very considerable disturbances from 6h. 10m. continued for many hours after.
12	Nov. 4.	15	4	Disturbance, commenced 11h., with a large wave, amp. 11′, period 1h., followed by another large wave, amp. 6′, period 25m., minute and irregular waves between.
13	„ 27.	15	37	No disturbance preceding, but minute oscillations shown after 17h. 30m., amp. about 1′.
14	Dec. 8.	22	59	Slight disturbance at 19h., Dec. 7, consisting of a wave, amp. 3½′, period 1h. 20m., commencing 18h. 20m., followed by very minute oscillation of amp. under 1′.
15	„ 19.	22	14	Very minute disturbance at 19h. 37m., consisting of a small wave, amp. under 2′.

1893.

16	Jan. 28.	21	26	Minute and irregular oscillations commencing at 17h. 10m., amp. generally under 1′, but in one wave at 19h. 10m., and in another at 19h. 34m., the amp. is 3′.
17	„ 31.	1	59	No disturbance.
18	„ „.	22	19	Very slight disturbance shown, consisting of minute oscillations, commencing at 19h. 27m., max. amp. 2¼′ at 20h. 15m.
19	Feb. 6.	14	47	Curve considerably disturbed from about 11h. 30m. Sudden and more marked disturbance at 12h. 0m., amp. of oscillation being 9′, another marked oscillation at 14h. 47m., amp. 7¼′ in opposite phase from the former. Followed by a large wave, period 1h., amp. 6′ in opposite phase to the preceding. This wave is superimposed by minute oscillations.
20	„ „.	16	44	Minute waves of very short period following after from 16h. 30m. for several hours afterwards, amp. from under 1′ to 2½′.
21	„ 9.	15	53	Very minute oscillations from 17h. 50m. continued for more than 4h., max. amp. about 1½′. Only one of these is somewhat more conspicuous than the others, this occurring at 18h. 55m. and perhaps another at 20h. 0m.
22	„ „.	19	20	(see 21)
23	„ „.	20	40	(see 21)
24	„ 13.	14	40	No disturbance.
25	„ 16.	2	57	Curve disturbed considerably from 22h., Feb. 15, but shows no special characteristic to indicate the commencement of a sudden disturbance. The curve shows a series of waves of irregular period and slightly varying amp. not exceeding 3′ generally; but one wave is quite conspicuous. This occurs at 8h. 40m. max. phase, period 1h. 20m., amp. about 10′ (ten minutes of arc).
26	„ „.	9	44	(see 25)
27	„ 21.	4	53	No disturbance preceding a wave, amp. 3′, commences 6h. 25m., ends 6h. 57m., followed by two minor very minute waves ending 7h. 45m.
28	„ „.	11	58	Curve almost normal, a few very minute oscillations, amp. under 1′ occur from 11h. 10m. and continue for nearly 12 hours after; of these only one is somewhat more conspicuous than the other. This occurs at 13h. 25m., amp. about 2′.

		M.M.A.T. H.	M.	
29	Feb. 22 .	20	56	Minute oscillations occur throughout for about 13 hours preceding this given time. The most conspicuous of these small and irregular oscillations occurs at 11h. 35m., period 28m., amp. 3′.
30	Mar. 2 .	20	46	Very minute oscillations commence at 18h. 25m., continued till 22h., amp. under 2′.
31	„ 14 .	4	0	No disturbance preceding. The curves commence to be disturbed at 7h. 30m.: oscillations at first very small, but greatly increasing after 11h. 30m., considerably disturbed for more than 30 hours after.
32	„ 20 .	14	50	No disturbance whatever.
33	„ 23 .	18	23	Very slight disturbance commencing 15h. 20m., consists of a small wave, period 5m., amp. 1½′, followed by other very minute waves, amp. under 1′.
34	April 8 .	11	31	Decided disturbance commenced at 7h. 0m., consisting of a large oscillation, period from 7h. 0m. to 8h. 27m., amp. 7¼′, with some minute waves superimposed.
35	„ 17 .	3	28	Very slight disturbance at 2h. 15m., showing a small oscillation, period 15m., amp. 1½′, followed by a few almost inappreciable waves, amp. only a few seconds of arc.
36	„ 23 .	11	12	No disturbance.
37	„ 29 .	15	42	Disturbance commencing 8h. 30m. consisting of two consecutive waves, period about 25m., amp. 4′, followed by a few very minute oscillations.
38	May 2 .	7	38	No disturbance.
39	„ 18 .	12	19	Disturbance commencing 12h. 19m., ending 15h. 10m., consisting of a sudden small oscillation amp. under 2′, followed by four waves, period 45m., amp. 3′.
40	May 18 .	22	43	Small oscillation at 22h. 25m., period 10m., amp. under 2′.
41	„ 23 .	18	18	Very slight disturbance, commencing at 17h. 15m., amp. of oscillation about 2′, period one hour.
42	June 3 .	14	5	No disturbance.
43	„ 7 .	19	50	Curve for this day slightly disturbed throughout its length. No particular disturbance shown for some hours before or after the given time.
44	„ 11 .	18	49	Curve for this day slightly disturbed throughout its length. No particular disturbance shown for some hours before or after the given time.
45	„ 13 .	8	45	No disturbance.
46	„ 14 .	4	27	Very slight disturbance (if it can be so called) at 3h. 45m., consisting of a small oscillation, period 20m., amp. about 1′. This curve shows oscillations of this kind throughout at irregular intervals. Probably this should not be called a disturbance.
47	July 3 .	7	45	Minute oscillations throughout the curve. No special disturbance showing.
48	„ 5 .	9	4	No disturbance.
49	„ 10 .	9	54	No disturbance.
50	Aug. 1 .	23	23	Disturbance very slight at 18h. 15m., consisting of a small wave, period 30m., amp. under 2′.
51	„ 3 .	22	32	Very minute disturbance at 16h. 55m., consisting of a small wave or oscillation, period 9m., amp. under 2′.
52	„ 6 .	17	22	This curve is very much disturbed throughout; but it shows two very conspicuous and larger disturbances, viz.:—One from 8h. 20m. to 9h. 50m. with amp. of 17′, and another with amp. of 11′, at from 10h. 5m. to 10h. 40m.
53	„ 10 .	18	49	Minute disturbance commencing at 19h. 55m., consisting of a series of minute waves, max. amp. 1½′.
54	„ 14 .	17	28	Disturbance commencing at 5h. 10m. and continuing till 17h., but gradually decreasing in amp. from 5½′ to nothing.

1894.

		M.M.A.T. H.	M.	
55	Mar. 22 .	8	17	Large disturbance commencing suddenly (after a long series of minor oscillations) at 5h. 30m., max. amp. 21m., curve disturbed throughout its length.
56	Apr. 20 .	15	22	Curve somewhat disturbed throughout, but a slightly more marked disturbance is shown at 14h. 0m., with an amp. of 4¼′.
57	„ 27 .	17	35	Disturbance (slight) at 9h. 55m., rather sudden displacement of 3½′, followed by a series of oscillations of very small amplitude and long period.
58	„ 29 .	1	5	Very minute series of oscillations commencing at 23h. 10m., April 28, ending at 23h. 55m., amp. under 2′.
59	June 20 .	3	25	Small oscillations appear throughout the curve. No special disturbance noticeable.
60	July 10 .	8	10	Same as above, but a slightly larger oscillation occurs at from 6h. to 7h., amp. 3½′.
61	„ 12 .	11	57	Disturbance at 9h. 20m., rather sudden displacement of 5′, followed by a series of minute oscillations.
62	Oct. 7 .	9	20	Disturbance commencing 8h. 0m., with a displacement attaining its maximum of 6′ in 20m., then followed by a long series of minute and short waves for four hours.
63	„ 22 .	6	40	Disturbance at 11h. 4m., rather sudden displacement of 4′, returning to normality at 12h. 40m.
64	„ 27 .	18	48	Disturbance commencing 11h. 15m., curve continued disturbed for 11 hours after; but there are two oscillations more conspicuous than others; one of these occurs at 15h. 20m., amp. 6′, period 50m., and the other at 18h. 0m., amp. 5′, period 35m.

1895.

		H.	M.	
65	Jan. 18 .	12	17	Curve slightly disturbed throughout, viz:—From 22h. January 17 to 22h. January 18; but shows two waves, or displacements a great deal more conspicuous than all others. One of these occurs at from 7h. 20m. to 7h. 55m., being a wave of 4′ amp. The other is a sudden displacement of 8½′, and occurs at 18h. 0m.
66	July 8 .	20	23	Curve slightly wavy throughout. No special disturbance noticeable.
67	Aug. 9 .	15	18	Large disturbance from 5h. to 7h. 30m., consisting of a single wave, amp. 11′, superimposed by minute and irregular waves, amp. under 2′.
68	Nov. 13 .	19	11	Curve disturbed at several places. The most conspicuous displacement occurs between 17h. 0m. and 18h. 0m., consisting of a wave of 10′ amp., followed by short minute waves for several hours.

1896.

		H.	M.	
69	June 16 .	9	26	Disturbance commencing at 8h. 5m. showing a wave, period 45m., amp. 8′. Another larger displacement commences at 10h. 40m., amp. 12′, curve considerably disturbed for the following 12 hours.
70	„ 29 .	18	42	Curve very slightly wavy (minute oscillations amp. under 2′) from 16h. to 22h. No special disturbance.
71	Aug. 26 .	21	2	Slight displacement commencing 11h. 55m., ending 13h. 30m., amp. 5′, followed by a series of minute oscillations, amp. less than 1′.
72	„ 31 .	6	3	No disturbance.
73	Sept. 5 .	21	42	Curve disturbed largely at several places, conspicuous isolated disturbance at from 6h. 20m. to 7h. 15m., amp. 12′. Another at from 14h. 40m. to 15h. 5m., amp. 8′, followed by minute and short waves till 20h.

		M.M.A.T. H.	M.	
74	Sept. 14.	8	10	Slight disturbance at 6h. 55m., being a wave period 20m., amp. 2½′.
75	„ 22.	2	33	Conspicuous isolated disturbance at from 6h. 30m. to 7h. 30m., being an oscillation with amp. = 11½′.
76	Nov. 1.	2	58	No disturbance.

1897.

		H.	M.	
77	Jan. 10.	18	58	Very minute oscillations, amp. under 2′, commencing 14h. 8m., continued for 5 hours, then at 19h. 40m. a slightly larger oscillation occurs, amp. 2½′, followed by another of same amp., but opposite phase.
78	June 12.	9	9	No disturbance.
79	Aug. 4.	22	2	Very slight oscillations of small amp. about 2′, and long period, commencing at 14h. 50m. Hardly to be called a disturbance.
80	Sept. 20.	17	4	No disturbance.
81	„ 21.	3	8	No disturbance.
82	Dec. 28.	18	34	
83	„ 29.	9	20	

VIII. *Form of Reports.*

It is desirable that Reports on Earthquakes should contain the following information :—

1. Greenwich Mean Civil Time (midnight = 0 or 24 hrs.) of the commencement of motion.

2. The duration of the *first* preliminary tremors (P.T.'s) usually represented by a broadening of the normal line.

3. The interval between the commencement of motion and the maximum motion.

4. The interval between the maximum and its apparent repetition, which, when it occurs, does so a few minutes later. This is the interval 1 to 1′ seen in fig. 3, p. 229.

5. The amplitude or half-range of the maximum motion expressed in millimetres and seconds of arc.

6. The total duration of the disturbance.

7. For large earthquakes a contact print, or at least a tracing of the disturbance, may be appended.

8. The time, duration, and amplitude of isolated broadenings of the normal trace. These must not be confounded with air tremors.

For the ordinary working of the instrument, see 'Brit. Assoc. Report,' 1897, p. 137.