

III. Periods of vibration.

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

TABLE XIII.
PERIODS OF VIBRATION. (GROUP I EARTHQUAKES.)

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

In the above table, the corresponding periods in the different portions are placed in the same horizontal rows; the periods most frequently occurring in each portion being printed in fat letters. The averages of the different sets of periods, deduced by taking the

means of the different values in the same horizontal rows are given in the following table; the corresponding results for Hongō (Tōkyō) being taken from the observations between July 1898 and Dec. 1899, given in the *Publications*, No. 5, p. 40. The notations P's there employed are the same as those here employed, except for the introduction of P_0 , P'_4 , and P'_8 .

TABLE XIV.
PERIODS OF VIBRATION IN DISTANT EARTHQUAKES.

Hitotsubashi and Hongo.

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

The period P_0 seems to be proper to the soil of Hitotsubashi. All the other periods are, however, not local in character, being nearly equal for Hitotsubashi and Hongō. P_1 occurs most frequently in the 1st preliminary tremor, while P_2 occurs very often in the 1st and the 2nd preliminary tremors, the 3rd phase of the principal portion and in the end portion; P_3 being also most frequent in the same four epochs. The periods P'_4, P_4 and P_5 frequently occur in the 1st three phases of the principal portion, while P_6 and P_7 occur almost exclusively in the first two phases of the same portion.

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

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

TABLE XV.

 PERIODS OF VIBRATIONS AT HITOTSUBASHI.
 [EARTHQUAKES OF GROUPS II-IX.]

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

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

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

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

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

those of P_4 , P_5 , and P_6 types, occurred very rarely; this circumstance arising from the fact that the earthquakes of Groups II to IX were mostly small earthquakes.

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

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

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

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