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

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

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

$$x = 7{,}27 \; y.$$

Hence we obtain the results :—

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

or

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

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

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

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

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[*] The table relates to the EW component alone.

TABLE XLI.

REPETITION OF MAXIMA IN THE EARTHQUAKE
MOTION AT HITOTSUBASHI.

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

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

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

The repetition of maximum movements at regular intervals may be explained by supposing that the earthquake motion at Hitotsubashi is composed of the proper oscillations of the soft surface soil mixed up with the motion of the underlying harder ground. That the proper oscillations always exist to a considerable amount at Hitotsubashi can be inferred from the approximate uniformity of the period of vibration at the latter in different cases ; the average period in the principal portion of the earthquakes of Groups VIIIA

and VIIIB varying mostly between 0,64 and 0,99 sec. with a mean value of 0,82 sec. (See Table XV.) The range of motion due to the underlying strata, which is probably not much different from the surface ground at Hongō, may be taken as being equal roughly to $\frac{1}{9}$ of that of the other kind of motion; the motion at Hongō being about half of that at Hitotsubashi. (See the *Publications*, No. 11.) Under these suppositions, the state of earthquake shaking at Hitotsubashi may be approximately represented as the resultant of the following two motions :—

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

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

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

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

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* 1 *shaku* $=0,994$ foot.

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

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

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

and

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

in which t denotes the time, and a_1 is supposed to be twice as large as a_2. The resultant motion has an average period of 0,33 sec.; while the maximum vibration occurs every 4 sec., which is approximately equal to the value actually found from observation, namely, 4,3 sec. That the above is a 'probable explanation of the phenomenon in question, which may be called *seismic beats*, may be inferred from the existence of the mean periods of 0,37 and 0,19 sec. in the motion of the ground surface ; these being practically identical with, and equal to half of, the period assumed for the motion x_2, namely, 0,36 sec.

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

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