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

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I. Introduction.

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

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

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

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

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

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

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

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

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

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

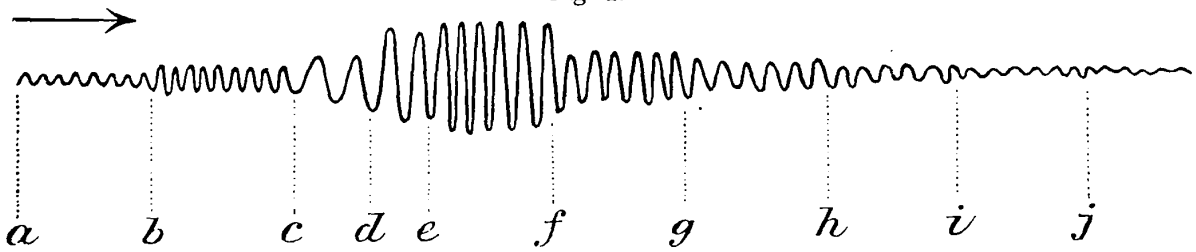
Group VIII, B.—Local unfelt earthquakes, nowhere recorded by Gray-Milne seismographs. (118 earthquakes).

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

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

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

Fig. 1.



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

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

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

The *preliminary tremor*, which consists principally of vibrations

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

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

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

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

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

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

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

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

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

II. Results of the observations at Hitotsubashi.

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

Date and time of occurrence;

Total duration;

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

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

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

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

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

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

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