2. *A Study on the Initial Motion of Earthquakes.**

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The initial motion of earthquake is extremely useful to determine the epicentre, to study the mechanism of occurrence of earthquake and to deal with the motion of a seismograph. Hence, it is necessary to study how the initial motion begins. The writer has studied the beginning portion of earthquake-motion in comparing the record of Ishimoto acceleration seismograph[1] with that of displacement seismograph.

The number of earthquakes here studied is twelve, which originated within a distance of about 160 km from Tokyô and the comparison was made with respect to the initial motion of vertical component only, because in the beginning phase the vertical motion is more conspicuous than the horizontal. Instruments used and their constants are shown in the following table.

	Period (without damping)	Geometrical magnification	Damping
Seismograph (Imamura's type)	4·5 sec	28	no damping
Acceleration[2] seismograph	0·15	215	critical

The direction of earth-movement is indicated in the same manner both in the diagram of seismograph and that of acceleration seismograph. Comparative study has been carried out with respect to the diagrams which are enlarged from the original seismographic record such that one second of time corresponds to 5 mm in length.

A few examples are shown in Fig. 5, Fig. 6, Fig. 7, and Fig. 8,

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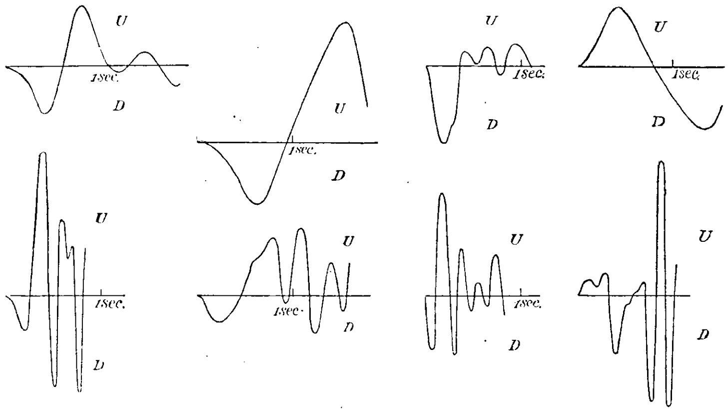
* Communicated by T. Matuzawa.

1) M. ISHIMOTO, *Bull. Earthq. Res. Inst.*, **11** (1933), 717.

2) The value of solid friction acting upon the recording index and the pivots is about 0·4 dynes which corresponds to the acceleration of 0·006 gal in the deflection of the recording index.

and the transcriptions of the initial portions are shown in Fig. 1, Fig. 2, Fig. 3, and Fig. 4.



Upper ; displacement-seismogram.
Lower ; acceleration-seismogram.

Fig. 1 (after Fig. 5) Fig. 2 (after Fig. 6) Fig. 3 (after Fig. 7) Fig. 4.

As will be seen from the figures, the very first throw of the initial motion lies in the same direction both in the record of seismograph as well as acceleration seismograph and the first maximum of the former corresponds to the second maximum of the latter, which lies in the opposite direction. For subsequent motions any definite relation as above stated is not apparent, this being probably due to complexity of motions. It is natural that the acceleration of the initial movement is in the sense, in which the initial displacement begins and the first maximum displacement corresponds to the second maximum acceleration in the opposite direction on the seismogram.

The period of registered motion ranges between 0·5 sec and 0·8 sec in the record of seismograph and between 0·25 sec and 0·7 sec in the record of acceleration seismograph. Consequently, both registered motions are interpreted without further dynamical reduction to be the displacement and the acceleration respectively of earth movement.

In case of somewhat large earthquakes, the relation mentioned above is not so clear as in case of moderate earthquakes. This is probably due to the fact that the initial motion in the former consists of a slow commencement of large amplitude superposed by quick vibrations, so that the former movement is favourably registered by a seismograph, whilst the latter by an acceleration seismograph.

What type of the initial motion is the most probable one which gives the most consistent explanation of the observed result as to the relation between displacement and acceleration? As it can be plausibly assumed that the initial motion may be a certain kind of shocks, a type of motion, the displacement of which is expressed by e^{-at^2}, may be considered as a probable one[3], where t is the time and a is an arbitrary constant. As we are here discussing only the first movement, the later stage of the motion above mentioned should be put out of question.

When the displacement of the initial motion x is expressed by

$$x=e^{-t^2},$$

then the velocity and the acceleration are as follows.

$$\frac{dx}{dt}=-2te^{-t^2}, \quad \frac{d^2x}{dt^2}=2(2t^2-1)e^{-t^2}.$$

As may be seen from Fig. 9a and Fig. 9c, the relation of x to $\frac{d^2x}{dt^2}$ is generally consistent with that of displacement of initial motion to its acceleration actually observed. Consequently, though there may be other possible types of earth motion, the observed fact can be explained at least by this type of motion. Further, the motion here proposed begins with the initial condition such that displacement, velocity, and acceleration commence from zero, which is also considered to be most natural.

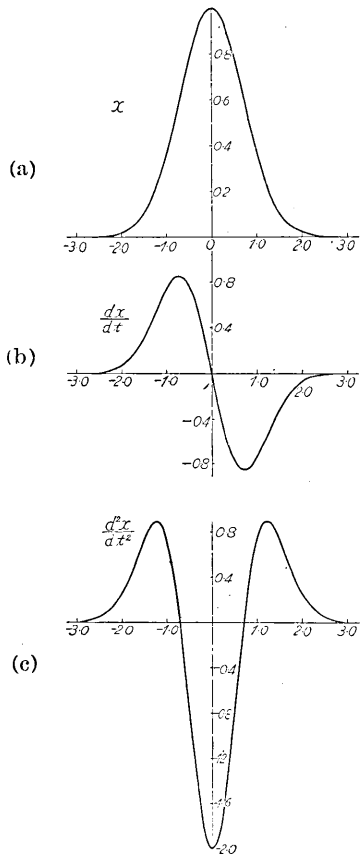


Fig. 9.

The motion of pendulum corresponding to the case in which the earthquake-motion begins with sinusoidal type has been already discussed by Saem. Nakamura[4], T. Matuzawa[5], H. P. Berlage[6],

3) This is due to Professor Ishimoto's suggestion.

4) Saem. Nakamura, *Journ. Meteor. Soc. Japan*, [ii], 2 (1924), 109.; *Proc. Imp. Acad.*, 3 (1927), 32.

5) T. Matuzawa, *Proc. Imp. Acad.*, 3 (1927), 68–71.

6) H. P. Berlage, „Untersuchung des De Quervain-Piccard'schen Seismographen und einiger allgemeiner seismometrischer Probleme," (1924).

and H. Kawasumi[7]. In the next occasion the writer wishes to report on some results with respect to the motion of pendulum when it is subjected to a special type of shock as above stated.

In conclusion the writer wishes to express his best thanks to Professor M. Ishimoto and Professor T. Matuzawa for their kind guidance and advices.

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2. 地震動の初動に就いて

地震學教室 鈴 木 武 夫

同一地震の加速度地震計の初動と變位地震計の初動とを比較して見ると，最初地動の變位と加速度とはその向きが一致し變位が第一の最大振幅に達する時に加速度は反對方向に最大になることが多くの場合認められる．地震動の初動が e^{-at^2} (t は時間) にて表はされる様な衝擊性の變位を以つて始まると假定すれば，上述の變位と加速度との關係が都合よく説明される様である．

7) H. Kawasumi, *Disin* (*Earthquake*), 4 (1932), 15.

Displacement-seismogram Acceleration-seismogram

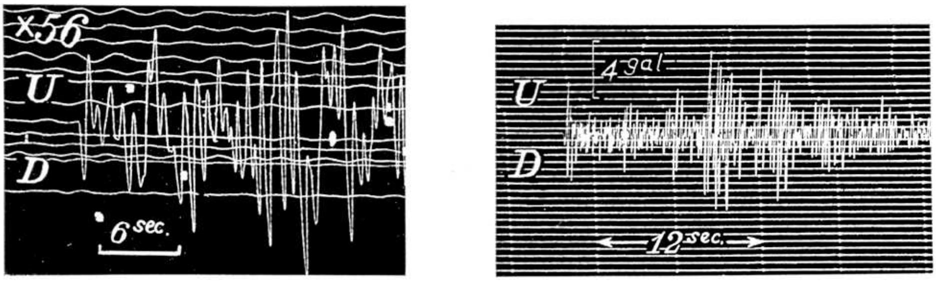

Fig. 5. Earthquake of July 26, 1931.

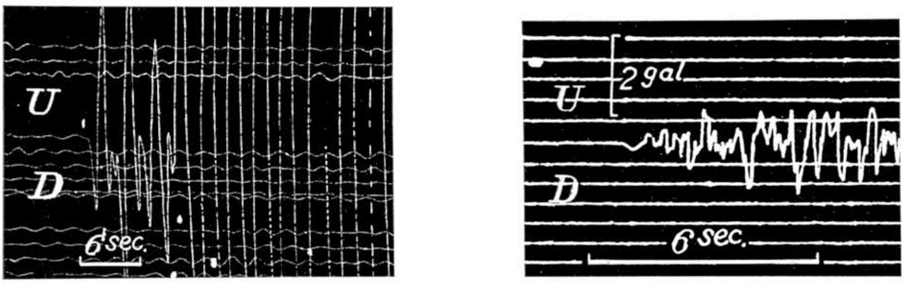

Fig. 6. Earthquake of June 22, 1932.

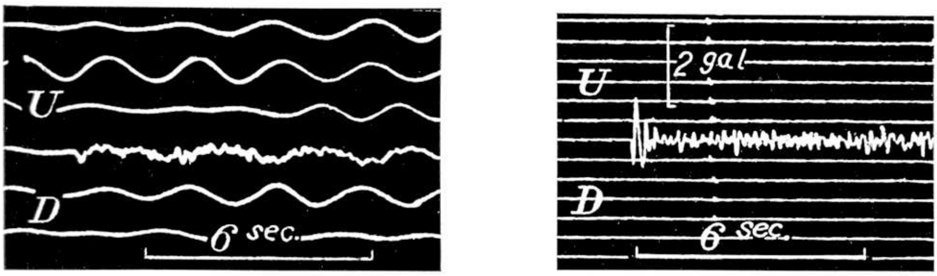

Fig. 7. Earthquake of March 24, 1932.

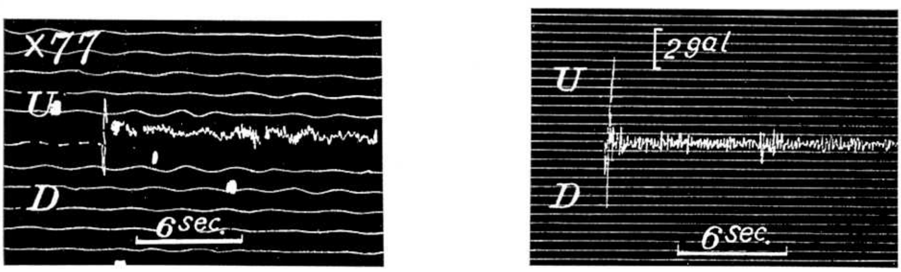

Fig. 8. Earthquake of July 13, 1932.

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